frontiers | Research Topics

Current trends in environmental psychology, volume I, 2nd Edition

Edited by
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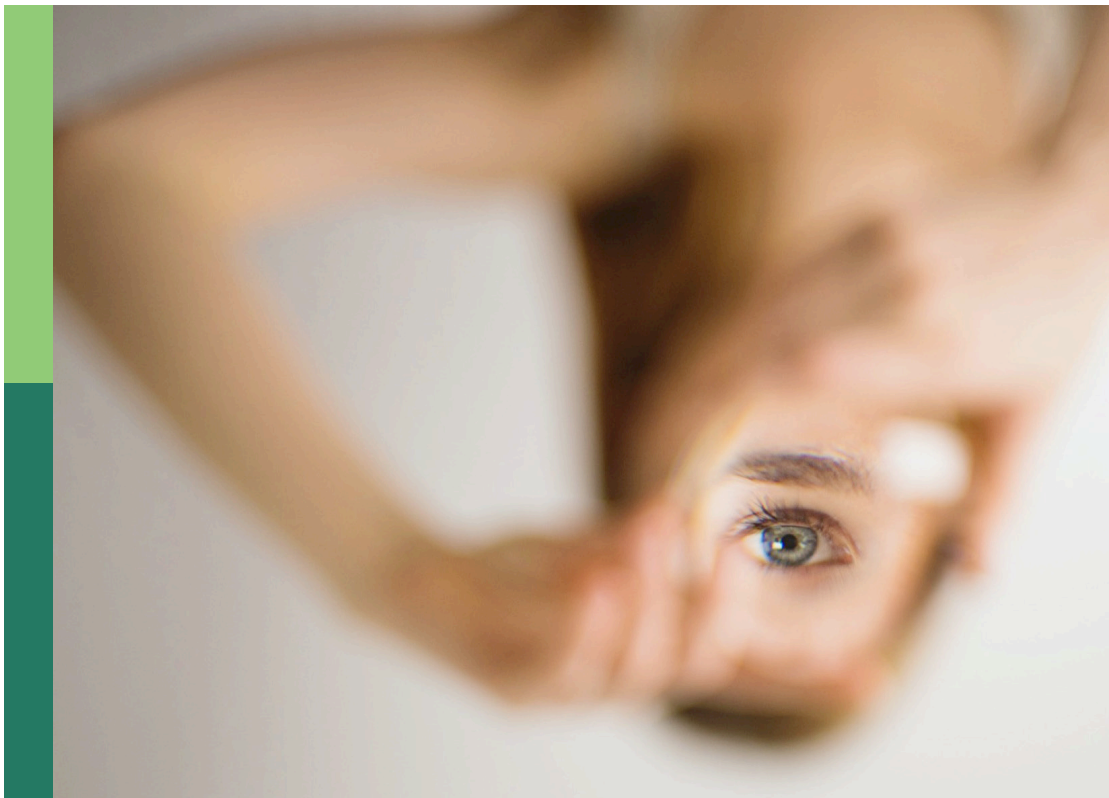

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Current trends in environmental psychology, volume I, 2nd Edition

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Table of contents

06 Editorial: Current trends in environmental psychology, volume I
Eugenio De Gregorio, Federica Caffaro, Sabine Pirchio, Lorenza Tiberio and Giuseppe Carrus

08 Socio-Psychological and Design Features Related to Transport Choices: A Focus Group Research in the Metropolitan Area of Cagliari (Sardinia, Italy)
Sara Manca, Francesca Ausilia Tirotto, Nicola Mura and Ferdinando Fornara

21 Body and the Senses in Spatial Experience: The Implications of Kinesthetic and Synesthetic Perceptions for Design Thinking
Jain Kwon and Alyssa Iedema

35 Evaluation of Daylight Perception Assessment Methods
Gizem Izmir Tunahan, Hector Altamirano, Jemima Unwin Teji and Cosmin Ticleanu

52 Conceptual Integration and Empirical Validation of a Unified Taxonomy: Quantitative Data Analysis for Virtual Learning Environments
Melanie Moreno-Barahona, Blanca Fraijo-Sing, Ghozlane Fleury-Bahi, Oscar Navarro-Carrascal and Cesar Tapia-Fonllem

59 Effect of Frugality and Cognition on Forest Health Tourism Intention–A Mediating Effect Analysis Based on Multigroup Comparison
Ying Li, Qiang Han and Ting Wen

73 Informal Earth Education: Significant Shifts for Environmental Attitude and Knowledge
Tessa-Marie Baierl, Bruce Johnson and Franz X. Bogner

81 Cross-Cultural Awareness and Attitudes Toward Threatened Animal Species
Jennifer Bruder, Lauren M. Burakowski, Taeyong Park, Reem Al-Haddad, Sara Al-Hemaidi, Amal Al-Korbi and Almayasa Al-Naimi

98 Integrating Observation and Network Analysis to Identify Patterns of Use in the Public Space: A Gender Perspective
Sergi Valera and Hernan Casakin

115 A Qualitative Study on Emotions Experienced at the Coast and Their Influence on Well-Being
Marine I. Severin, Filip Raes, Evie Notebaert, Luka Lambrecht, Gert Everaert and Ann Buysse

130 Social Workers' Choice Making in Supporting Nature Activities by Parents and Children in Shelters
Elise Peters, Dieuwke Hovinga, Jolanda Maas and Carlo Schuengel

140 The Need for Sustainability, Equity, and International Exchange: Perspectives of Early Career Environmental Psychologists on the Future of Conferences
Jana K. Köhler, Agnes S. Kreil, Ariane Wenger, Aurore Darmandieu, Catherine Graves, Christian A. P. Haugestad, Veronique Holzen, Ellis Keller, Sam Lloyd, Michalina Marczak, Vanja Međugorac and Claudio D. Rosa

150 Predicting Pro-environmental Intention and Behavior Based on Justice Sensitivity, Moral Disengagement, and Moral Emotions – Results of Two Quota-Sampling Surveys
Susanne Nicolai, Philipp Franikowski and Susanne Stoll-Kleemann

169 Contextual and Individual Variables as Predictors of Energy-Dense Meals in Food Choices
Daniela Borbón-Mendívil, Cesar Tapia-Fonllem and Blanca Fraijo-Sing

175 Should I Stay or Should I Go? Risk Perception and Use of Local Public Transport During the COVID-19 Pandemic
Anna Helfers, Marissa Reiserer, Natalie Schneider, Mirjam Ebersbach and Carsten Sommer

196 The Psychological Impact of Global Education Approach to SDGs. A Study on Emotions and Sustainability Attitudes of European Teachers
Marco Boffi, Nicola Rainisio and Paolo Inghilleri

208 Environmental threat in France: Two studies testing the effect of threatening messages on system justification and environmental denial
Hélène Labarre and Marie-Line Felonneau

216 Eco-anxiety in children: A scoping review of the mental health impacts of the awareness of climate change
Terra Léger-Goodes, Catherine Malboeuf-Hurtubise, Trinity Mastine, Mélissa Généreux, Pier-Olivier Paradis and Chantal Camden

237 A goal-framing perspective on the important aspects of energy-efficient multifamily buildings
Pimkamol Mattsson and Maria Johansson

252 What does the public think about microplastics? Insights from an empirical analysis of mental models elicited through free associations
Marcos Felipe-Rodriguez, Gisela Böhm and Rouven Doran

263 Give Up Flights? Psychological Predictors of Intentions and Policy Support to Reduce Air Travel
Jessica M. Berneiser, Annalena C. Becker and Laura S. Loy

281 Climate change opportunities reduce farmers' risk perception: Extension of the value-belief-norm theory in the context of Finnish agriculture
Jaana Sorvali, Xing Liu and Janne Kaseva

293 Consistent or inconsistent? The effects of inducing cognitive dissonance vs. cognitive consonance on the intention to engage in pro-environmental behaviors
Lucia Bosone, Marie Chevrier and Franck Zenasni

302 Linking environmental psychology and critical social psychology: Theoretical considerations toward a comprehensive research agenda
Thomas Kühn and Sebastian Bobeth

319 A systematic review to assess the evidence-based effectiveness, content, and success factors of behavior change interventions for enhancing pro-environmental behavior in individuals
Henriette Rau, Susanne Nicolai and Susanne Stoll-Kleemann

343 Thermal demands and its interactions with environmental factors account for national-level variation in aggression
Qingke Guo, Sisi Li, Jinkun Shen and Jianli Lu

353 Environmental integration tool approach: Self-determined commitment and the adoption of pro-environmental behaviors
Vincent Henin and Paula Uglione

366 A one-hour walk in nature reduces amygdala activity in women, but not in men
Sonja Sudimac and Simone Kühn

379 Has the COVID-19 pandemic strengthened confidence in managing the climate crisis? Transfer of efficacy beliefs after experiencing lockdowns in Switzerland and Austria
Stephanie Moser and Sebastian Seebauer

394 The other blue: Role of sky in the perception of nature
Izabela Maria Sztuka, Ada Örken, Sonja Sudimac and Simone Kühn

410 The contour effect: Differences in the aesthetic preference and stress response to photo-realistic living environments
Nour Tawil, Leonie Ascone and Simone Kühn

427 Sustainability pedagogy: Understanding, exploring and internalizing nature's complexity and coherence
Nicole Spiegelaar

443 Factors influencing the financing behavior of large professional households engaged in green agricultural production in China
Shen Zhong, Xueting Xu, Junwei Li and Nanlin Wu

456 Can carbon labels encourage green food choices?
Swen J. Kühne, Ester Reijnen, Lea Laasner Vogt and Melanie Baumgartner

468 The relationship between student's perceptions of their school environment and academic achievement
Edward Edgerton and Jim McKechnie

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Editorial: Current trends in environmental psychology, volume I

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Editorial on the Research Topic
Current trends in environmental psychology, volume I

This Research Topic on "*Current trends in environmental psychology, volume I*", which is linked to the 3rd International Conference of Environmental Psychology (ICEP 2021), held in Siracusa, Italy, 4–9 October 2021, constituted an enormous challenge. Our proposal was aimed to promote an interdisciplinary turnaround in environmental psychological thinking, at a time when major existential challenges posed by the raise of new technologies in everyday life settings (homes, workplaces, hospitals, schools, green areas, urban open spaces), and by the worsening of the global emergency at the planetary level, seem to be at their peak.

The still ongoing transformations of human social life induced by the COVID-19 pandemic, and in general different ways of interacting and communicating are bringing about significant changes in terms of models and methodologies in different areas of psychological science, including environmental psychology.

Through the call for papers of this RT, we wanted to reconstruct and debate the new research trends within the field of environmental psychology. Beyond the specific fields of application covered in the papers included in this RT, this experience has shown us how broad the scientific community is within the disciplinary context of environmental psychology, in terms of methods, theories and contents of investigation.

Foundational matters have been re-evaluated and brought up to date, such as experimental research on the perception and representation of spaces, the effects of heat on aggression, and the psychological basis of sustainable behavioral choices. For example, in this Research Topic, studies have been included attempting to identify the possible rationale in human behavior regarding environmental protection in different contexts (urban and rural, coastal and mountain). All these are classic themes of environmental psychological research.

Some articles have also taken up other classic themes of environmental psychology, reinterpreting them in a modern key and referring to theories that seemed to have been forgotten, perhaps because linked to a deterministic perspective that gradually became less popular in present-day psychology and in particular in environmental psychology.

Significant relevance is devoted to the challenges posed by people's public transport choices (air and road) also in connection with the recent COVID-19 pandemic. In the pandemic and post-pandemic era, the issue of sustainable mobility intersects with that of health protection, with implications on the concept of 'all-round health' and planetary wellbeing. This aspect also makes it relevant to keep a closer look at policies and decision-making strategies for the promotion of social and environmental sustainability, for the conservation of biodiversity and protection of animal and vegetal species, to ensure the optimal functioning of earth's ecosystems.

An important application context, which is also covered in this RT, is that of educational settings, considered from the perspective of environmental psychology as spaces of action and thought where the values and strategies and actions of future generations are forged.

The pandemic issue is present in many papers and not only because of the problems it has brought to human life in the last 3 years, but also because of the value of discovering resources and people's sense of social adaptation: a tragedy, certainly, but also an adaptation resource that guided the discovery of new potential in human societies.

From a methodological point of view, many different approaches and research traditions are represented in this RT. We included studies that have made use of complex experimental designs and large scale surveys, as well as theoretical contributions and studies with a more general epistemological inspiration. Also, importantly, we included studies that have made use of qualitative methods.

Researchers from the Americas, Europe (in particular, Germany, Belgium and the Netherlands) and China have contributed to the co-construction of a collective scientific endeavor that at this moment has collected 58,000 views across 34 different papers.

Conclusion

In conclusion, it is also interesting to point out potential areas of improvement in present day environmental psychological research, namely the fact that an explicit, integrated and comprehensive methodological framework in environmental psychology (for example through new trends such as mixed methods) still needs to be defined and constructed by empirical research in our field, as represented by the various papers included in this RT.

Author contributions

All authors contributed equally to writing and revising the text of the editorial and to conceptualizing and editing the Research Topic.

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ORIGINAL RESEARCH
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Socio-Psychological and Design Features Related to Transport Choices: A Focus Group Research in the Metropolitan Area of Cagliari (Sardinia, Italy)

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Due to the environmental and health impact of the private transport sector, social scientists have largely focused on psychosocial and contextual factors associated with people's choice over transport means. This study aims to contribute to this line of research by applying a user-centered approach, with the objective of taking into account the specific environmental and social context of the metropolitan area of Cagliari city (Sardinia, Italy). To accomplish this aim, four groups of people were matched according to their shared starting point: car users vs. public transport users (Study 1), and light-rail users vs. non-light-rail users (Study 2). Groups were interviewed using a focus group method. Participants were invited to discuss their everyday travel experiences and to exchange their ideas on different sustainable (e.g., bicycles and public transport) and less sustainable (i.e., private cars) means of transport. Both consolidated drivers/barriers in the field of environmental psychology (e.g., perceived behavioral control, social norms) and public transportation design features (e.g., lighting) have been investigated. Other than highlighting the importance of socio-psychological factors to promote more sustainable transport choices like in previous studies, the present research offers an insight into how these aspects and factors are shaped and experienced in the narratives of residents.

Keywords: perceived behavioral control, social norms, safety, environmental stress, public transport, emotions

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INTRODUCTION

Limiting the use of private cars in favor of more sustainable transport choices, such as public transport and bicycle use, is associated with a range of positive environmental impacts (e.g., Brand et al., 2021) and health benefits (e.g., Patterson et al., 2020). However, the use of private cars rather than public transport still seems the most preferred means of urban transport in the European Union (Eurostat, 2021a). In fact, data pointed out that in the EU, there is a regional average rate of 0.54 passenger cars per inhabitant (Eurostat, 2021b). In particular, Italy has recorded the second-highest motorization rate (i.e., average number of passenger cars per inhabitant) among the EU countries, preceded only by Luxemburg (Eurostat, 2021b). Environmental psychology research has typically focused on the study of transport behaviors with the main aim to foster behavioral changes

in a more sustainable direction, through the identification of key psychosocial and contextual variables (e.g., Steg, 2005; Steg and Vlek, 2009; Donald et al., 2014). As demonstrated by the research literature, while interventions aiming to increase the use of sustainable transport choices *via* economic cues might have a positive effect in the short term, car drivers still prefer to use their car in the long term (Thøgersen and Møller, 2008). Thus, economic incentive alone seems to be insufficient to promote long term sustainable transport choices, which is consistent with the studies focused on other pro-environmental behaviors (e.g., Kaiser et al., 2020). Socio-psychological motives underlying people's transport choices have been widely investigated (e.g., Donald et al., 2014; Manca et al., 2019). However, the knowledge of the narratives supporting such choices in a given place, with its specific and unique features, cannot be obtained through quantitative studies. Furthermore, while the role of the physical environment in influencing people's attitudes, behaviors, and quality of life is well-known (e.g., Gifford, 2014), the effect of public transportation design (e.g., air conditioning, comfort seats, and in-bus features such as Wi-Fi) on travel choices has been substantially overlooked (Lombardi and Ciceri, 2021), even if some studies have highlighted its potential impact by focusing on the attractiveness of the light-rail (Hodgson et al., 2013). Consequently, how do users describe their everyday experience with transport choices? How are these experiences linked to the psychosocial constructs and contextual aspects such as design and aesthetic features of transports?

The present research has been carried out in the specific context of the metropolitan area of Cagliari city (Sardinia, Italy), through a "user-centered" approach (see Gifford, 2002) based on a qualitative-based content analysis strategy. As claimed by different scholars (Schwanen et al., 2011; Thomas et al., 2014), the qualitative methods can provide novel insights to better understand the motivations and views of the people about choices of travel mode, since such methods capture more detailed answers, and, thus, "overcome self-presentation biases and reveal the complexity of motivational structures" (Gardner and Abraham, 2008, p. 188). Hence, this approach provided a deep exploration of the everyday experience of the people with transports in the target place of analysis, i.e., the metropolitan area of the city of Cagliari. In particular, two distinct and complementary studies have been carried out to explore the everyday experience of the people with transport means. The first study looks at the narratives of both car and public transport users, while the second study focuses on the experiences narrated by both the light-rail users and the non-light-rail users.

RESEARCH RATIONALE

One of the main models used for the prediction of pro-environmental behaviors (Wolske et al., 2017), including transport choices (e.g., Heath and Gifford, 2002; Fu, 2021), is the Theory of Planned Behavior (TPB; Ajzen, 1991), which postulates that the direct antecedent of behavior is behavioral intention, but even perceived behavioral control can trigger such behavior directly (or indirectly through intention). Thus, people's assessment of their ability to perform a given behavior, for instance, in reaching the workplace by bus or by bike, is likely to influence their travel choice.

It has been shown that behaviors may be motivated not only by rational drivers, as postulated by expectancy-value theories such as the Theory of Planned Behavior, but also that affective motives seem to play an important role in influencing travel behavior (Bamberg and Schmidt, 2003; Kals and Müller, 2012) and to implicit attitude toward a sustainable transport (Manca et al., 2019), even though the weight of negative and positive emotions in predicting the intentions to change the way to act has not been clarified so far. The field of emotions is also related to the symbolic factors that may drive people to act in order to widely communicate their own personality, a group membership, or a social status. For instance, the choice to travel with a private and custom car can be due to socio-psychological drivers, such as the desire to highlight personal qualities, group affiliation, or social roles (Gatersleben and Steg, 2013; Moody and Zhao, 2020), and not just for more concrete features of the custom car such as speed and convenience. Among these socio-psychological drivers, social norms have received significant attention as a key dimension in affecting environment-related behaviors and, specifically, travel choices. This kind of social influence includes two types of norms: injunctive norms, which refer to beliefs about others' approval/disapproval of a person's behavior; and descriptive norms, which refer to people's beliefs about others' actual behavior (Cialdini et al., 1991) and represent cues to appropriate behavior for a given situation (Schultz et al., 2008). Both kinds of social norms have proven to have a significant impact on the promotion of sustainable transport choices (e.g., Zhang et al., 2016; Ru et al., 2018). Analytically, injunctive norm was found as a key predictor of public transport use (Thøgersen, 2006), sustainable travel choices (Piras et al., 2021), and car use intention, either in positive (Eriksson and Forward, 2011) or in negative terms (Gardner and Abraham, 2010); whereas descriptive norms emerged as a trigger of the intention to use both public transport and the bicycle (Eriksson and Forward, 2011).

Traveling in a more sustainable way draws attention to the relationship between people and their environment. For instance, sustainable transport choices such as moving on foot or by bicycle could allow a slower and more intense place experience. On a different level, the promotion of public transport use should suggest a specific attention on the appearance of waiting areas, such as bus stops or train/bus stations, whose design features could affect the travel experience of transport users, especially in terms of perceived safety (Loukaitou-Sideris, 1999; Kooi, 2015). In this regard, Abenoza et al. (2018b) have pointed out how particular sites, such as bus shelters and the surrounding environment of bus stops, may influence the perceived safety and crime perceptions of the travelers, which in turn affect the travel mode choice. It was also noted and supposed that the strong relationship between security and overall travel satisfaction (Abenoza et al., 2018a) can influence the intention to use public transport. Therefore, this research has focused on identifying which features of public transport waiting areas trigger people's security perceptions. A

literature review by Tucker (2003) reported that lighting, shelters, benches, the surrounding environment and their maintenance, and cleanliness are among the most important features to be considered when designing safe environments related to travel behavior. A recent study pointed out the strong effect of security and economic arguments as significant predictors of positive attitude toward sustainable transport (Manca and Fornara, 2019).

OBJECTIVE

The objective of this research is to explore the underlying motives of urban residents' travel choice in a specific target place. Cagliari, located in the south of Sardinia, is the main and most populous city of the island, as well as the port and the main Mediterranean cruise liner hub. Its metropolitan area hosts 17 municipalities with a total of 432.000 inhabitants. Specifically, the aim is to detect directly from the voices of the residents, the barriers and (possible) drivers for more sustainable transport behaviors, in order to better understand how to successfully promote alternative ways of urban mobility rather than using private cars. In fulfillment of this goal, we chose to run qualitative studies based on the focus group technique. In fact, the narrative material from focus group interviews allows to capture those beliefs, attitudes, feelings, and motivations as they naturally emerge from the responses of the speakers. The assumption is that such responses express the (more or less) shared views about the topic which are socially constructed within a given cultural context or social group (Bamberg et al., 2020).

Consistently with our methodological choice, we conceptually relied on a user-centered perspective (Gifford, 2002), which is particularly pertinent to deeply understand the needs of users to identify the main factors that may promote or inhibit sustainable mobility choices.

To date, the metropolitan area of Cagliari provides different choices to travel within it: a cycling network of about 70 km, bike and car sharing services, urban buses that covers the whole city and its suburbs, long-distance buses as links between the city and to other towns or villages of the region, and a recent light-rail system (i.e., a transport system using small trains that operates at a higher capacity and speed, on an exclusive right-of-way) running from the town around a part of its metropolitan area, operating but still with on-going developments (i.e., since April 2015 the light-rail system has been operational on two lines; in 2023 the network expansion will be completed and the inauguration of line 3 is expected).

Specifically, the exploration of views and experiences of the users that are related to different means of urban transport was carried out through two qualitative studies with the same framework but different targets: the first involved general public transport users (Study 1: car users vs. public transport users), the second one had a specific focus on the light rail (Study 2: light-rail users vs. non-light-rail users). Both studies were carried out in the city of Cagliari during the development of the light-rail, connecting various zones of its metropolitan area.

A set of environmental and socio-psychological dimensions were addressed in order to observe their impact in influencing attitudes toward ecological transport. On the basis of the current research literature, we expect an impact of design features (Hodgson et al., 2013), affective motives (Bamberg and Schmidt, 2003; Kals and Müller, 2012), and social norms (Zhang et al., 2016; Ru et al., 2018) on the sustainable travel choices of the users.

STUDY 1: CAR USERS VS. PUBLIC TRANSPORT USERS

Method

Participants

Participants ($N = 16$) were residents in the broad area of the city of Cagliari. To explore the beliefs of the residents who are mainly using different means of transport for their daily journeys, two distinct focus groups were carried out. Specifically, one focus group included public transport users, i.e., those individuals who regularly use public transport (urban and long-distance buses, bike, and light-rail) for most of their daily journeys, while the other focus group included those people who mostly use the private car for their daily moves. The group of public transport users had a total of 6 participants (33.3% men; age range 21–30; M = 25,5), while the group of car users was composed of 10 participants (40% men; age range = 19–33; M = 24,8). Concerning education level, the majority attended senior high school.

Procedure and Tool

The focus group technique was used for its suitability in detecting which aspects are the most relevant in influencing the personal travel choice (Clifton and Handy, 2001). Such a technique is based on the discussion of a group of individuals around a set of questions centered on a particular topic or set of topics, and its main objective is to generate conversations that reveal more or less shared opinions concerning a particular issue (Cyr, 2016). The strength point of the focus group material is due to its richness in terms of experiential information, if compared to other data collection methods (Carey and Smith, 1994).

The two focus groups were held by two moderators (i.e., a moderator and an assistant moderator, both co-authors of this paper) in a proper setting (i.e., a room equipped with movable chairs located at the Psychology Building of the University of Cagliari). The duration of each focus group was about 1 h. The moderator welcomed the participants, gave an overview of the topic, and laid out the ground rules. Participants were encouraged to talk spontaneously, and follow-up questions were used to facilitate further discussion of salient issues. The assistant moderator had the role of taking notes and supporting the moderator.

The tool prepared for this study is the focus group interview, which covered an array of 14 questions related to specific aspects—i.e., architectural, functional, and social—related to the transportation experiences. The extent to which each issue was explored was dependent upon its importance on the participants. Questions were based on five macro categories:

(1) Advantages and disadvantages of different means of transport [e.g., How would you describe your experience

with private (i.e., car and bicycle) and public (e.g., bus) means of transport? What do you think are the main advantages and disadvantages of these different means of transport?];
(2) Environmental, personal, and social consequences of different means of transport (e.g., What consequences come to your mind when thinking about the use of different means of transport? For you, personally? For the natural environment? For society as a whole?);
(3) Motivations to use their main means of transport (e.g., What are the motivations, for you personally, to use your main means of transport?);
(4) Motivations of other people to use different means of transport (e.g., Thinking about other people's choice of transport means, what do you think the main motivation behind their choices could be?);
(5) Environmental and architectural elements associated with means of transport (e.g., What comes to your mind when thinking about bus stops/stations/interiors?).

Each focus group was digitally recorded and fully transcribed.

Data Coding and Decoding

The content analysis procedure (Krippendorff, 2004) was performed on the two focus group transcripts. Two independent judges coded each focus group discussion following a theory-driven approach, i.e., identifying the relevant sentences and issues related to each topic based on the pre-defined conceptual categories (Hsieh and Shannon, 2005). Such categories concern respectively affect-based and instrumental-based evaluations (Steg, 2005; Manca and Fornara, 2019), perceived behavioral control (Ajzen, 1991), perceived safety (e.g., Ingvardson and Nielsen, 2021; Rahman et al., 2021), social norms (Cialdini et al., 1991; Bamberg et al., 2020), environmental stress (Novaco et al., 1979; Wallenius, 2004), and general environmental and architectural aspects (e.g., aesthetic features). Importantly, people referred to pre-existing categories even if no explicit question about the category was made. For example, the *perceived safety* category has often emerged when asking questions regarding the design features of means of transport.

Based on the aforementioned literature, the judges referred to a concise version of the definition of the construct during the coding process. For example, the affect-based topic was defined as "the extent to which a product is expected to lead to emotional outcomes such as pleasure." This allowed the judges to focus on the same meaning associated with the constructs of interest.

Each interview transcript was initially split into sentences. An Excel file was preliminarily prepared for this purpose. In this file, each row contained one sentence or unit of meaning. The judges co-constructed this preliminary file, based on the last author's recommendations. In particular, full stops and question marks mainly delimited a sentence; if a participant's opinion was formed by more than one sentence and the sentences together formed one unit of meaning, this case was classified as one sentence only. For example, "*If you have to come to Alghero by car, it's impossible to travel by ARST in Sardinia. For long distances it is impossible*" contains a full stop. However, the sentences are strictly connected to each other in terms of meaning, therefore, it was classified as one sentence. The only exception was when a second participant continued to discuss about the same unit of meaning of a first participant (as it typically occurs in a focus group discussion). In this case, the unit of meaning was separated in two sentences, as different participants contributed to them.

Both judges used the same coding scheme. The scheme was based on the following questions: Does this sentence refer to any of the pre-defined conceptual categories? Which categories? Does the sentence have a positive or negative valence? What is the sentence specifically referring to (i.e., Metro Station, Metro Stops, Metro Tram, Long Distance Buses, Long Distance Buses Station, Railway Station, Urban Bus, Urban Bus Stops, Car, and Setting)? After completing each row, judges answered two more questions: Does the transcript contain any other meaningful category that could not be fully interpreted in light of the pre-existing categories? What does the new category refer to?

Other than categorizing sentences, the data analysis also included the computation of two types of frequencies. The first type only focused on the number of times participants expressed opinions toward socio-psychological factors (i.e., affect evaluations, instrumental evaluations, perceived behavioral control, perceived safety, social norms, and environmental stress) and the environmental, as well as architectural aspects (e.g., design features). For example, the sentence "*The car is like a second home, a second bedroom*" was coded as 1 occurrence of the topic "*Affect-based evaluations*" in Study 1.

The second type of frequency was, instead, computed by counting the number of times that the participants expressed a positive or a negative opinion toward a certain transport mean (e.g., car, bus), or environmental and architectural aspects (e.g., bus station, design features) by type of user. The coding scheme for this type of frequency is presented in **Table 1**. Taking the same sentence as an example (i.e., *The car is like a second home, a second bedroom*), it was also coded as 1 *positive valence* occurrence for *car*, within the group *car users* of Study 1.

The use of the two analysts has allowed to assess the reliability of the coding process (see Golafshani, 2003; Carter et al., 2014). Finally, the two judges compared their content analyses and discussed the inconsistencies until they found an agreement. The degree of consensus/dissensus within each focus group concerning the topics that were dealt with was also analyzed. Participants pointed out an agreement on each addressed issue. Furthermore, as supposed, the choice to set up a group discussion gave the opportunity to each participant to add new details on the topic which were subsequently debated and further shared by the group, given an interesting wealth of content.

RESULTS

Some trends have emerged, like analyzing the frequency and the valence of the opinions about different means of transport. Specifically, car users have evaluated long-distance buses more negatively than public transport users did (see **Figure 1**). Furthermore, negative opinions toward the use of the bicycle were expressed over two times more frequently by car users (i.e.,

TABLE 1 | Example of coding scheme for the second type of frequency computed.

		Frequency				
Valence	**Object**	**PBU**	**CU**	**LRU**	**NLRU**	**Text**
Positive	Environ. and archit. aspects	–	–	–	–	–
	Bicycle	–	–	–	–	–
	Light-Rail	–	–	–	–	–
	Car	–	–	–	–	–
	Urban bus	–	–	–	–	–
	Long distance buses	–	–	–	–	–
Negative	Environ. and archit. aspects	–	–	–	-	–
	Bicycle	–	–	–	–	–
	Light-Rail	–	–	–	–	–
	Car	–	–	–	–	–
	Urban bus	–	–	–	–	–
	Long distance buses	–	–	–	–	–

PBU, public transport users; CU, car users; LRU, light-rail users; NLRU, non-light-rail users; Text, sentence extracted. ***Figure 1*** *(Study 1) and* ***Figure 3*** *(Study 2) present the results based on this scheme.*

14 occurrences) than those by the public transport users (i.e., 6 occurrences). It is also interesting to note that even though both groups present a similar frequency of negative opinions about urban buses, only public transport users reported a relevant number of positive opinions on urban buses (i.e., 9 occurrences); whereas, car users reported only 1 positive opinion about them. In **Figure 1**, percentages within groups are also shown. These were computed by initially weighting the raw frequency count by number of participants, then subsequently converting such proportion into percentage. Also note that the interpretation of the results is the same when using either raw frequencies or weighted frequencies.

Narratives on personal travel experience and means of transport choices were mostly focused on affect- or instrumental-based evaluations, respectively, with a total of 32 and 27 occurrences (see **Figure 2**). Environmental and architectural aspects concerning different means of transport and stations (or stops) consisted of 35 occurrences. The following paragraphs report the summary of the content analysis results for each conceptual category that was considered for this study. In general, discussions were about the selected pre-existing categories and no new category was introduced.

Affect-Based Evaluations

Participants reported their experiences and opinions by describing how they felt during travel by justifying their travel choices as related to the anticipated feelings. In particular, car users expressed their positive feelings on cars by mainly highlighting the concepts of freedom, independence, and the importance of personal space.

> *"(I need) to sit in my own place. I am a little fussy (…), it really annoys me (to be sitting in public transport seats). Furthermore, to be independent. If someone asks me to go out, then I say ok, I just take the car (and drive somewhere)."* Female, aged 25, Car user.

> *"(The car) is like a second home, a second bedroom."* Female, aged 30, Car user.

On the other hand, only the issue of general comfort emerged as a positive feeling associated with car use in public transport users.

Positive emotions about public transport were reported by both groups. The positive emotions concerned the feeling of relaxation derived from the pleasure of being taken to places without driving, the opportunities to look around and to interact with other people.

> *"As a positive side there's certainly the social interaction, because it's beautiful: we share those 5 mins the same experience of waiting. So if I find an old woman I help her to take the shopping bag; if you're talking about the university, they see you with the books and ask you what you study. That's already very interesting."* Female, aged 30, Public transport user.
>
> *"You have the "resignation" that another one will drive. That you don't have to drive."* Male, aged 25, Car user.
>
> *"I like the idea to look out of the windows rather than drive, instead if you are driving you have to watch the road."* Female, aged 21, Public transport user.

Similar feelings have been reported about the use of bicycles by both groups. Positive feelings concerned the opportunity to enjoy the surrounding environment. Furthermore, bicycle use has been described as more exciting compared to other means of transport. However, only public transport users reported to also use the bicycle for their daily travels, whereas car users only ride the bicycle for fun during their free time. Feelings of fear related to its use were expressed by car users.

> *"We used to ride our bikes and it was a wonderful opportunity to run around Cagliari city."* Male, aged 30, Car user.
>
> *"I can take a look around if I use the bicycle, instead you have to be more concentrated using the car, so I think that it is nicer."* Female, aged 21, Public transport user.

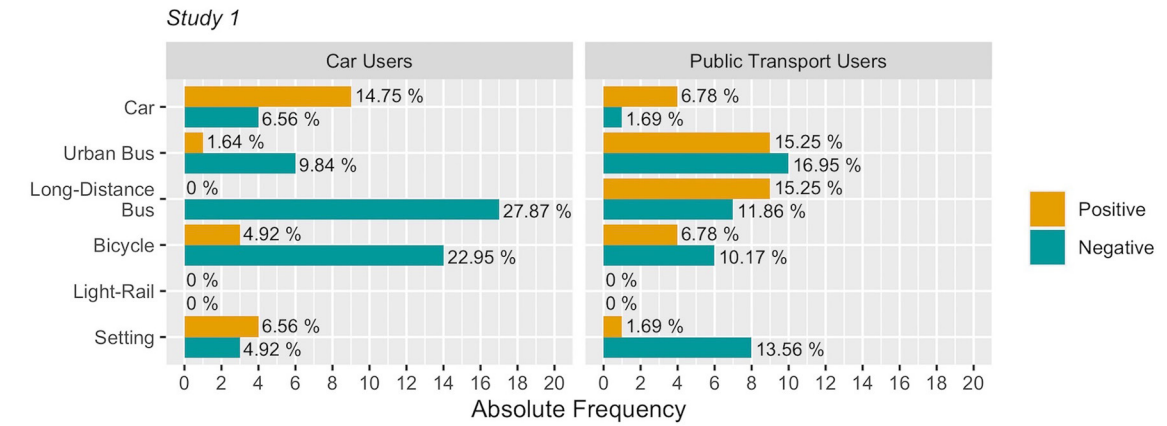

FIGURE 1 | Positive and negative frequencies of sentences associated with different means of transport and with architectural and environmental aspects (i.e., setting). Percentages are computed within each group.

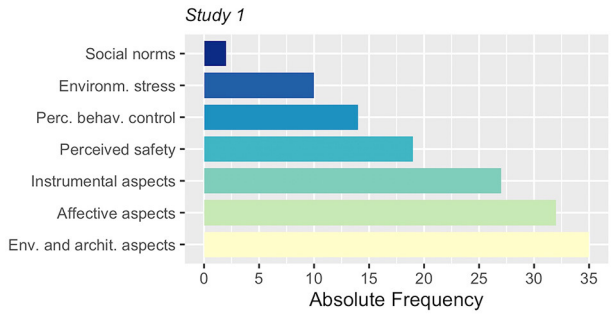

FIGURE 2 | Frequency of socio-psychological, environmental and architectural topics of the group discussions in Study 1.

Both groups of users defined the bus-station environment as uncomfortable, old, and unsafe.

> *"It is uncomfortable. Finding a homeless person with all his stuff on the benches can cause discomfort to a person who is there waiting for his bus/train."* Female, aged 24, Car user.
> *"The bus station is, in general, a bad environment. I have never felt totally safe."* Female, aged 25, Public transport user.

Instrumental-Based Evaluations

Economic factors and travel duration played an important role in the choice of means of transport. Both groups recognized that cars are more expensive means of transport and that public transport requires, usually, a greater travel time. The particular context of Cagliari city, in which the availability of parking places is very limited in the city center, led participants to highlight this problem, thus, motivating Public Transport users toward toward a more sustainable transport.

> *"I have to look for a parking spot when I go to San Benedetto Market, it requires too much time by car so taking a bus is faster."* Female, aged 24, Public transport user.

Environmental and Architectural Aspects

Structural environmental aspects of Cagliari city appeared to widely affecting the willingness of people to use the bicycle in the focus group discussions. In particular, the presence of several hills, potholes, and few and inadequate cycle paths have been reported as the main perceived obstacles.

> *"The cycle paths are very narrow. There is a narrow cycle path also in Via Paoli that, as you said, people open the car door and kill you."* Male, aged 21, Car user.

Public transport users expressed a complete dissatisfaction toward structural aspects of urban bus stops. These users defined them as unsuitable to cover people from rain and reported the lack of adequate electronic bus timetables in several bus stops.

> *"Yes because in many bus stops there aren't. If it rains, you get wet, you have to wait for the bus and you can't sit down. I think it is a pretty fundamental thing."* Female, aged 30, Public transport user.

Concerning the aesthetic factors, bus stations for long distance buses were evaluated by both groups as unpleasant and dimly lit. A similar judgment has been reported concerning long distance buses, described as antiquated. Instead, there was no negative judgment about the aesthetic characteristic of urban buses, rather the Public Transport users evaluated them as new and comfortable.

Perceived Behavioral Control

Users agree with a sense of disorientation and of waste of time in reference to inadequate structures and services (e.g., lack of electronic timetables) that are supposed to support travel behavior with public transport. The perceived difficulty to use Public Transport has been highlighted by both groups against long distance buses, particularly reporting electronic timetables as too far from bus stops and the impossibility to know in advance the availability of empty seats.

"There is a board here with tiny timetables that you have to look for. You go there and the first driver you find, you try desperately to ask him which bus you have to take, because you have to go there and you don't understand anything." Female, aged 33, Car user.
"Let's say that what the ARST lacks is perhaps one of those computerized signs with timetables on the inside where the buses stop. To see the timetables, you have to go inside and look at the big board and search for your town. In the meantime, your bus will leave." Female, aged 19, Car user.
"A conception of time gives more security in terms of time and anxiety, because if I know it starts at 1 p.m. for Sassari, I don't if the driver changes his mind, not because he wants it but because there isn't really space, I don't know if I can really take the bus or not. You have different timetables but if you miss one you risk leaving the next day or waiting for the next one, anyway you have to wait four hours. For me personally it makes a big difference." Female, aged 24, Public transport user.

Within the Public Transport users, there were mixed opinions concerning long distance buses. In fact, some of them also reported a positive perceived control in talking about the easiness of finding departure time information and reporting it as normally on-time.

"There aren't bus problems, there are always on time, information is given to you by everybody, both the drivers and the ticket sellers." Female, aged 21, Public transport user.

Differently, especially for long distances, cars are a means of transport that are perceived as more reliable and easier to use compared to long distance buses in Cagliari. The perceived ease of bicycle use has been reported as highly compromised by the slopes due to the hilly character of the city.

"If you have to come to Alghero by car, it's impossible to travel by ARST in Sardinia. For long distances it is impossible." Female, aged 24, Public transport user.

Perceived Safety

Feelings of security have been reported around all means of transport, except for bicycles by both users.

"Cycle paths are so narrow, there is also in Via Paoli next to the road, as you said, the drivers open the car's door and they kill you." Male, aged 21, Car user.

Bus stations were indicated as unsafe, especially from the evening onwards. Participants reported a lack of adequate lighting and video surveillance in this place. An interesting aspect concerns the relevance of the surrounding environment for the perceived safety. In fact, even though there was a general agreement between users about the perceived safety in travel by buses, participants reported how their feelings of security were affected by the surrounding environment around stations and bus stops.

"On the bus you are safe, maybe on the street you are not." Male, aged 25, Car user.
"If I see him getting off at the same stop as me, I won't get off." Female, aged 25, Car user.
"(In Piazza Matteotti) the lighting at night would certainly improve a little. If you are around, you can see someone attacking people." Male, aged 25, Public transport user.

Social Norms

Participants were aware that the willingness to use the bicycle is also affected by perceived social norms that may be different depending on the culture of a country. In particular, car users claimed that in other countries, bicycles are a more common and important means of transport, evaluated as appropriate.

"We also lack culture because I have been to Germany, Belgium, and England. It's very different there. [. . .] It's completely different here. The bicycle can stay in a very small place." Male, aged 30, Car user.

Environmental Stress

The main environmental stressor identified by car users was related to the temperature on the public transport. It has been reported that it is usually too high or too low, with the unpleasant consequence of being sweaty or being cold during the journey. Instead, the possibility to regulate the temperature inside the car at will was reported as one of the benefits of using a car from the point of view of the car users. Public transport users focused on the stress caused by traffic that requires high levels of alertness while driving.

"In fact, I've noticed this: in this period when it isn't that cold, they turn the heaters on at most, so it is a sauna. I swear to you. (. . .) I was so sweaty. If you want to offer me also a shower service, (. . .) that is to say, in winter there is a shocking cold instead in summer or in spring they turn the heaters at most." Female, aged 33, Car user.

STUDY 2: LIGHT-RAIL USERS VS. NON-USERS

Method

Participants

Participants ($N = 13$) were residents in the broad area of the city of Cagliari. Here, the focus was the on-going development of the Cagliari light-rail "MetroCagliari," hence, light-rail users vs. non-users were distinguished. Following the same methodology of Study 1, two focus groups were held: the group of light-rail users had a total of 7 participants (71,4% men; age range 29–60; M = 41,3), and the group of non-users was composed of 6 participants (50% men; age range 21–49; M = 29). Concerning the education level, the majority attended senior high school.

Procedure

The interview was designed following the same structure of Study 1, although different and more specific questions about the light-rail were posed and a new topic was introduced, consistent with the innovation valence as expected for the use of this means of transport. In fact, the new topic concerns the extent to which light-rail users/non-users evaluate transport choices as meaningful for people's status in the society (Steg, 2005; Moody

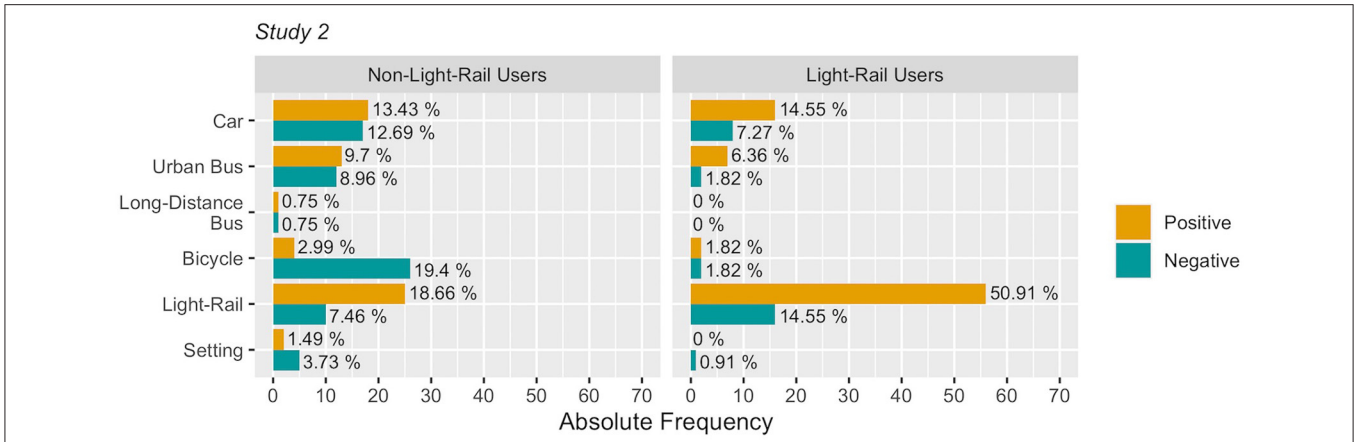

FIGURE 3 | Positive and negative frequencies of sentences associated with different means of transport and with architectural and environmental aspects (i.e., setting). Percentages are computed within each group.

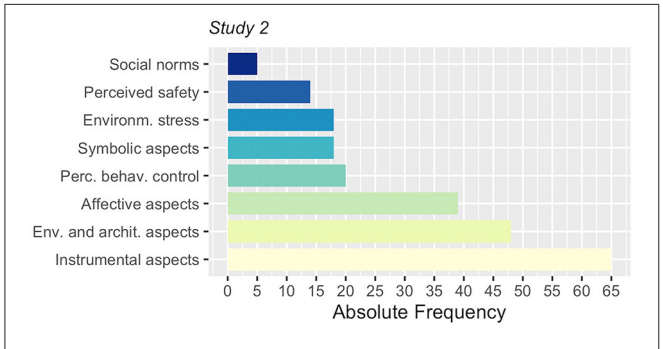

FIGURE 4 | Frequency of socio-psychological, environmental and architectural topics of the group discussions in Study 2.

and Zhao, 2020). Data analysis procedure is equal to the one in Study 1.

RESULTS

Light-rail users expressed a considerable amount of opinions toward light-rail, with a total of 56 positive sentences and 16 negative sentences (see **Figure 3**). Opinions toward light-rail by non-light-rail users were, as well, more positive than negative. Instead, opinions toward urban buses by non-light-rail users were well balanced between positive and negative evaluations. The discussion concerning the use of bicycles by non-light-rail users was mostly focused on the negative aspects of it, with a total of 26 negative sentences. The amount of positive and negative opinions toward the car by non-users was similar (**Figure 3**).

The motivation underlying the participants' transport choices mainly focused on the instrumental and the affective aspects (see **Figure 4**). A large part of the discussion has also been reported on the architectural and environmental aspects that are related to transportation.

Affect-Based Evaluations

The consideration of the car as more than a simple means of transport has been confirmed in the second study by car users. Consistently with Study 1, feelings of freedom and independence related to car use have been repeatedly reported by both users.

> *"The car is a very personal environment; a person traveling by car is alone with himself."* Male, aged 29, Light-rail user.

The valence of the emotions changed when participants focused on the relationship between different drivers. Participants reported nervousness and hatred as negative feelings that arise while driving.

> *"In the car, I curse you for not letting me go to the stop."* Female, aged 23, Non-light-rail user.
> *"Another thing can be related to the relationship between people; that is, for example, in the car I always see nervous people as if they were all against each other."* Female, aged 23, Non light-rail user.
> *"The relationship that exists in the car completely changes people. On the contrary, when a cyclist meets another cyclist on the road, they greet each other. In the car people are at their worst."* Male, aged 43, Light-rail user.

On the contrary, as in Study 1, possible contacts between people during a bus ride seemed to positively contribute to the choice of public transport as means of transport.

> *"Taking public transport means to share an environment with other people and this may be appreciated by some."* Male, aged 29, Light-rail user.
> *"I don't say to be also willing to talk, but anyway a smile might be given to a person."* Female, aged 23, Non-light-rail user.

Non-light-rail users reported a general sense of satisfaction in using bicycles, but, as in Study 1, they also perceived this means of transport as related to free time, especially reporting that the cycle

paths in Cagliari were mostly arranged for recreational travels (e.g., beaches, parks).

> *"The cycle paths are for pleasure at the moment and not for use: they are placed in places for walking rather than for going to certain places."* Male, aged 21, Non-light-rail user.

Fatigue and fear were the most mentioned feelings by non-light-rail users during the bicycle discussion.

Instrumental-Based Evaluations

As in Study 1, economic factors and travel duration motivated the choice between public transport and car use. Cars are perceived as more expensive than public transport, and the latter is perceived as a means of transport that requires greater travel time. The lack of parking areas has also been reported in Study 2 as a motivation to use public transport. Furthermore, participants reported that the use of the light-rail decreases the number of issues related to traffic problems, making the travel time shorter than with other public transport use, thus, increasing the willingness to use the light-rail instead of the car.

> *"The light-rail would be much faster than the bus and maybe even the car."* Female, aged 23, Non-light-rail user.

Light-rail users pointed out a problem related to a lack of integration between urban buses and light-rail services that could potentially limit the use of a more sustainable transport.

> *"The lack of integration with the CTM public transport; the fact that there is a public transport's stop at Via Gottardo which it isn't in front of the light-rail and that the "University Express" bus doesn't stop in front of Policlinico: it is ridiculous, despite the fact that there are these two services, there isn't the possibility to arrive quickly coming from Settimo and to continue toward the Brotzu Hospital, because the bus passes under the light-rail without stopping."* Male, aged 43, Light-rail user.

Environmental and Architectural Aspects

The willingness to use bicycles emerged to be compromised, as in Study 1, by inadequate cycle paths and, most of all, by strenuous hills. Non-light-rail users especially stressed these problems, rather than light-rail users who focused more on the inability to get the bicycle inside the light-rail and to use both bicycle and light-rail in the same travel.

> *"The light-rail should have more places for bikes because a maximum of two bikes per ride doesn't encourage the use. Only two bikes per ride can be taken."* Male, aged 30, Light-rail user.

Light-rail stops have been evaluated as inappropriate to cover people from rain and wind and to be isolated from the residential area. This issue has also been stressed in Study 1 concerning urban bus stops. A different opinion has been reported about the internal environment of the light-rail and of its stations. In fact, users reported to be fully satisfied with it, considering the inside of the light-rail to be more comfortable, aesthetically pleasing, and spacious than the urban and long-distance buses, as well as appreciating the light-rail environment of the station.

> *"The light-rail is more comfortable because it is larger and more spacious."* Male, aged 23, Non-light-rail user.
> *"I liked the benches, the baskets, the structure."* Female, aged 49, Non-light-rail user.

Perceived Behavioral Control

Users perceived cars as easier to use than general public transport, while the light-rail as easier to be used than urban buses. In fact, light-rails allow users to know exactly when they will arrive at the destination, while the car is described as a means of transport that has the unparalleled feature to be used at any time with large autonomy. Also in this study, the hilly slopes of the city negatively affect the perceived control about bicycle use.

> *"(Cagliari) is a city where it is difficult to travel every day by bike."* Male, aged 23, Non light-rail user.

Perceived Safety

As in Study 1, participants declared to feel different levels of safety in the different means of transport, evaluating bicycles as a serious threat for people's life, and describing the surrounding environment of some light-rail stops as dark and consequently less safe. In general, the presence of video surveillance inside a light-rail, its station, and in light-rail stops made these environments safer as perceived by the light-users.

> *"(On a bike) you risk your life."* Female, aged 30, Non-light-rail user.

Social Norms

Light-rail users explicitly declared that the choice to use light-rail is affected by perceived social norms. Participants reported that citizens use the light-rail more than the urban buses because it is socially considered as more appropriate. In order to explain that, they justified the choice of using the light-rail as related to a current fashion trend among Cagliari residents. Furthermore, participants reported that seeing people using the light-rail increases chances to use the same public transport by other people.

> *"It's a matter of trend, because there is the name in front of the light-rail; because in the end it is a light-rail, it is the same light-rail that was there in 1950s-60s, which is repaired in a modern and comfortable way."* Male, aged 43, Light-rail user.
> *"I think that if more people take the light-rail, more people are interested in taking the light-rail; It is a circular thing."* Male, aged 30, Light-rail user.

Environmental Stress

Only noise pollution, as an environmental stressor, was reported being frequently present in the light-rail. Instead, the environmental stressor identified in the urban bus was related to the feeling of crowding, while stressors for those in cars related to the traffic problem.

"I've noticed that often on the light-rail there is, this maybe can't be solved, it is too noisy, I mean I continue to hear that sound wuuuufff." Male, aged 29, Light-rail user.

Perceived Status of Light-Rail Users Stress

Participants focused on the difference between light-rail users and users of other public transport methods such as long-distance buses and urban buses. Light-rail was perceived as a transport used by all walks of life in which even those in high corporate positions use this type of transport. It is important to consider that in Cagliari city, public transport is mainly used by students and less-favored social classes.

"For example, a friend of mine who brags takes the light-rail; She doesn't take the bus because of the smell, the light-rail is for the elite." Female, aged 49, Non-light-rail user.
"The point of view of some professionals has changed, in fact you sometimes see lawyers, magistrates, and police officers going to Piazza Repubblica by light-rail." Male, aged 43, Light-rail user.
"Those few times I have traveled by bus, I've noticed that there is a slightly different environment, a slightly lower level (than in the light-rail)." Male, aged 39, Light-rail user.

DISCUSSION AND CONCLUSION

The present qualitative research sheds light on people's beliefs and attitudes related to the transport choices of residents in a specific target place, i.e., the metropolitan area of the city of Cagliari. Focus group material has allowed the emergence of both cognitive and emotional factors, as barriers or drivers of such choices, that should be considered in order to develop proper strategies for changing a kind of environment-related behavior, such as the use of the private car, that is typically based on habits (Bamberg et al., 2003).

Outcomes of the two studies showed an array of features contributing to the choice of travel behavior and to satisfaction toward the means of transport. (Un)safety, (dis)comfort, and economic aspects emerged as relevant dimensions in influencing the behavior of both usual and potential users of sustainable transport. In this regard, the importance of socio-psychological constructs such as perceived behavioral control and social norms seemed confirmed. Besides, the relevance of design features (such as lighting, space, and architectural elements) in the narratives of the respondents suggests that design issues should be considered in promoting public transport, which represents a more sustainable travel mode than the private car. Improving the design features could also exert a positive influence on symbolic and affective values related to public transport choices. To date, no have investigated if and how these different pathways may interact in the field of public transport choices. From the present study, pleasant aesthetic features, along with modern and cutting-edge means of transport, were associated with people holding higher status positions in society, compared with those from unpleasant aesthetic features. Future studies should investigate this possible interaction since symbolic outcomes associated with car use have been shown to be extremely important (e.g., Lois and López-Sáez, 2009; Moody and Zhao, 2020). We propose that promoting symbolic outcomes could (i) mitigate the effect of those symbolic outcomes associated with car use, and (ii) attract more car users to explore the use of public transport. The importance related to the general symbolic factors on travel mode has also been pointed out by Murtagh et al. (2012a) from an identity-based perspective. The authors showed that the degree to which people identified themselves with a certain social category (e.g., parents, workers, motorists) has influenced their willingness to use different means of transport (i.e., car and public transports). In this sense, the authors concluded that multiple and competing identities can influence the transport choice decision, and that the centrality and the salience of a certain identity can push the preference of an individual of his/her travel means. In another study, Murtagh et al. (2012b) have also shown that changes in travel mode could be perceived as a threat toward identity motives (i.e., self-esteem, generalized self-efficacy, continuity, and distinctiveness). In interpreting the current research results in light of Murtagh's work, public transport design features and efficiency improvements may support people's identity motives such as self-esteem and self-efficacy, thus, resulting in an easier transition toward more sustainable transport means.

Likewise, the development of modern and cutting-edge means of transport such as light rails has been shown to contribute to a positive "place of image" of the city (Ferbrache and Knowles, 2017). Therefore, the implementation of new means of public transport needs to consider the consequences associated with cultural and identity aspects of the citizens and of the city as a whole. While opinions toward light-rails were mostly positive in the present research context, the temporary disruption in the streets during the installation phase of light rails, along with changes of the general image of the urban environment, could potentially and negatively interfere with people's place attachment (e.g., Anton and Lawrence, 2016; Von Wirth et al., 2016; Clarke et al., 2018; Reese et al., 2019).

Consistently with other research findings (see Ellaway et al., 2003), a higher perceived security is associated with the use of a private car, whilst, on the other hand, public transport is viewed as unsafe. The necessity of individuals to protect their own personal space (see Hall, 1966) appears to be particularly salient in transport choices, as already noted in previous literature (Mann and Abraham, 2006). All respondents reported that both the presence of crowds and the narrowness of the settings decrease feelings of protection, and, consequently, the use of public transport.

With concern to the role of architectural elements in enhancing the perception of security, this research confirms the evidence which emerged in other settings (e.g., the stadiums: Manca and Fornara, 2015). More specifically, spatial and physical features were indicated as crucial in providing a positive travel experience. The proper lighting of stations, waiting areas, bus stops, and vehicles emerged as strongly related to higher security and satisfaction levels in the narrative of the respondents. In particular, most women showed feelings of fear and anxiety related to journeys in places that are poorly lighted, thus, preferring the use of a private car in reducing the potential risks of being assaulted. Enhancing the overall perceived behavioral

control of the users seems to promote a better opinion on sustainable transport, thus, confirming the salience of this pattern for the promotion of pro-environmental responses (e.g., see Wolske et al., 2017; Fornara et al., 2020). The access to an interactive service information (e.g., electronic signs, timetables, routes) was mentioned as a key element for reducing the uncertainty related to the waiting time and the real transit of the bus. Therefore, architectural elements constitute a crucial aspect in influencing attitudes toward sustainable transport and travel choices. These outcomes suggest that design features should be taken more into account in the planning of both external environments (i.e., stations and bus stops) and of the interior of the public vehicle to increase the safety of the passengers, and, consequently, to promote the use of a travel mode that is an alternative to the private car.

The importance of economic arguments in orienting transport choices is another point that emerged from focus group narratives, thus, confirming what was found in other studies (Wardman, 2001; Jakobsson et al., 2002; Manca and Fornara, 2019). More specifically, people show a biased perception of their travel cost, since public transport tickets were valued as too expensive when compared with the fuel cost of the private car. In this regard, a positive influence on attitudes toward public transport has been pointed out in studies that tested the potential role of free tickets (Fujii and Kitamura, 2003; Ayako and Satoshi, 2007), underlining the persistent use of buses after the free period. Thus, economic incentives should be implemented together with the provision of a comfortable and safe transport service.

The pattern of frequency related to psychosocial and contextual variables associated with transport means was consistent among the two studies. In particular, instrumental, affective, environmental, and architectural aspects were the most frequent topics discussed, while social norms were the less frequent topic. The latter corroborates with studies addressing the role of people's awareness of social influence on their everyday choices. In fact, people tend to underestimate the effect of social norms on their individual behavior, despite norms being one of the strongest behavioral predictors (Nolan et al., 2008).

This study presents several limitations. First, participants consisted of adults and young adults, future studies should also consider the elderly who might present different needs and experiences. Second, the educational level of our samples was similar. All participants had at least a high-school diploma. Therefore, our findings may be affected by socio-demographics. Another limitation concerns the transferability of the findings. We suggest these findings to be relevant for similar social contexts where social norms strongly sustain car use. For example, narratives among car users and public transport users may include different contents when considering citizens living in Amsterdam (i.e., where bicycle use is very common). Moreover, large municipalities offer multiple and various transport options such as feasible mobility services (e.g., Uber, subway), which were not available in the context of the present study. A further limitation concerns the novelty associated with the implementation of the light-rail in the present context of study. In fact, future studies should verify if and how people's opinion toward new public transport developments may differ according to the installation phase of the project. In fact, Ferbrache and Knowles (2017) highlighted the importance of carrying out longitudinal research to capture the changes in people's narrative in the long-term in similar research contexts.

In light of designing new spaces such as waiting areas, bus stops, and means of transport, these findings highlight a set of users' needs that could increase the use of sustainable travel choices such as public transport. Opting for strategies that improve the user experience in public transports might be particularly useful for those lacking in environmental motivations to use public transport (e.g., De Groot and Steg, 2009). In conclusion, by employing a user-centered approach (Gifford, 2002) and evidence-based guidelines (Hamilton, 2003), the present study sheds light on actual and potential experience, preferences, and needs of the users that are related to sustainable travel choices.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: Qualitative study with focus groups recording in Italian language. Requests to access these datasets should be directed to Sara Manca, saramanca@email.it.

AUTHOR CONTRIBUTIONS

SM: contributed to conceptualization, methodology, investigation, data analysis, and first-draft writing. FT: conceptualization, methodology, investigation, data analysis, and writing (reviewing). NM: methodology, investigation, and data analysis. FF: conceptualization, methodology, and writing (reviewing). All authors contributed to the article and approved the submitted version.

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Body and the Senses in Spatial Experience: The Implications of Kinesthetic and Synesthetic Perceptions for Design Thinking

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Human perception has long been a critical subject of design thinking. While various studies have stressed the link between thinking and acting, particularly in spatial experience, the term "design thinking" seems to disconnect conceptual thinking from physical expression or process. Spatial perception is multimodal and fundamentally bound to the body that is not a mere receptor of sensory stimuli but an active agent engaged with the perceivable environment. The body apprehends the experience in which one's kinesthetic engagement and knowledge play an essential role. Although design disciplines have integrated the abstract, metaphoric, and visual aspects of the body and its movement into conceptual thinking, studies have pointed out that design disciplines have emphasized visuality above the other sensory domains and heavily engaged with the perception of visual configurations, relying on the Gestalt principles. Gestalt psychology must be valued for its attention to a whole. However, the theories of design elements and principles over-empathizing such visuality posit the aesthetics of design mainly as visual value and understate other sensorial and perceptual aspects. Although the visual approach may provide a practical means to represent and communicate ideas, a design process heavily driven by visuality can exhibit weaknesses undermining certain aspects of spatial experience despite the complexity. Grounded in Merleau-Ponty's notion of multisensory perception, this article discusses the relationship between body awareness and spatial perception and its implication for design disciplines concerning built environments. Special attention is given to the concepts of kinesthetic and synesthetic phenomena known as multisensory and cross-sensory, respectively. This discussion integrates the corporeal and spatiotemporal realms of human experience into the discourse of kinesthetic and synesthetic perceptions. Based on the conceptual, theoretical, and precedent analyses, this article proposes three models for design thinking: Synesthetic Translation, Kinesthetic Resonance, and Kinesthetic Engagement. To discuss the concepts rooted in action-based perception and embodied cognition, this study borrows the neurological interpretation of haptic perception, interoception, and proprioception of space. This article suggests how consideration of the kinesthetic or synesthetic body can deepen and challenge the existing models of the perceptual aspects of environmental psychology adopted in design disciplines.

Keywords: design thinking model, spatial perception, interior design and architecture, kinesthetic perception, synesthetic perception, sensory experience, multisensory design, embodied design

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INTRODUCTION

Spatial perception involves the tangible elements of the setting and the intangible attributes, including atmosphere and energy, and the cognitive process of the multimodal (or cross-modal in some cases) sensory input. The spatial experience is fundamentally bound to the body that is not a mere receptor of sensory stimuli but an active agent that engages with the perceivable environment and apprehends the experience in which the senses mediate the relationship between mind and body as well as idea and space (Mandik, 2005). While studies from various disciplines have shown the link between mind and body or thinking and acting (Schön, 1983; Durão, 2009; Wilde et al., 2011; Kwon, 2018; Sheets-Johnstone, 2019; Tversky, 2019), the term "design thinking" seems to disconnect conceptual thinking from physical expression or manifestation, which appears to echo body–mind dualism (Wilde et al., 2011; Loke and Robertson, 2013; Sheets-Johnstone, 2019; Domingo et al., 2021). The body is not separate from the mind, and the way the human being perceives space is interdependent on the physical structure of the body. In the domain of represented space that is apprehended through perceptual and sensorial mechanisms, mobility is the primary vector and provider of meaning (Durão, 2009, p. 399). Cognitive neuroscience studies have found the relationship between perception and motor action in aesthetic experience and creative productivity (Hurley, 1998; Torrents et al., 2013); the connection of users' visuospatial experience with locomotive behavior (Hoogstad, 1990; Tversky, 2005). However, the movement and position of the body have not much been discussed in relation to creativity and design thinking while the human body has long been a popular subject in design education, research, and practice concerning anthropometrics, human factors, and ergonomics that aim to decrease human errors and increase productivity and safety in the utilitarian use of the products. Despite the generally accepted perspective design can help mediate one's existing movement or change its movement patterns (Fogtmann et al., 2008, p. 91), there has been a lack of consideration of body movement as a sensory modality and the ground for the possibility of spatial experience (Farnell, 2012).

While design education and research have integrated the conceptual, metaphoric, and visual aspects of movement (e.g., sense of movement in visual repetition of the same shape) into the early phases of design process, studies have criticized that design disciplines have emphasized the visuality above the other sensory domains (Attfield, 2000; Garner, 2018; Sheets-Johnstone, 2019). They heavily engage with the expression and perception of visual elements (Pallasmaa, 2005), emphasizing the visual aspect of Gestalt principles, which does not adequately explain the corporeal and kinesthetic aspects of spatial perception. Ponzo et al. (2018) pointed out "the contribution of certain modalities, such as the vestibular system and interoception, to multisensory integration and body ownership has only recently been studied and hence remain poorly understood" (p. 312). Despite such concerns, the theory of design elements and principles posits the visual qualities as the primary aesthetics of design and understates the importance of the other senses. Although the visual approach may provide a practical means to represent and communicate ideas, a design process heavily driven by visual aspects can exhibit weaknesses undermining other aspects of the human environment. Thus, any theory that restricts perception to a particular modality fails to fully explain diverse sensory phenomena, especially in multidimensional space (Svanæs, 2013).

Another issue is that approaches to human perception sometimes seem overly analytical, the consequence of which is that the senses are often treated as if they worked independently from one another. Individuals' perceptions and interpretations of their surroundings become highly multimodal upon occupying and experiencing a space (Pallasmaa, 2005; Dischinger, 2006; Franck and Lepori, 2007; Heylighen et al., 2009; Heylighen, 2011; Wastiels et al., 2013; Kwon and Kim, 2021). While the sensation is partial, the senses are distinct yet indiscernible; they are united through the body in becoming its perception, argued Merleau-Ponty (2014). Merleau-Ponty's phenomenology of perception provides conceptual and theoretical insights into body, senses, and perception, as it concretes human existence, including subjective human experience, intentionality, action, perception, and meaning (Moran, 2000; Seamon, 2015). Crucial to the inquiry in environmental design is the phenomenological translation of the essence of one's action and perception into architectonic dimensions, not only the examination of the impact of material elements on aesthetic or practical use. Due to the multidimensional, multimodal, and multisensory nature of spatial perception, no single methodology or prescriptive measure can sufficiently explain human responses to the spatial attributes and sensory stimuli (Budd, 2011). Regardless of some controversy, the reciprocal contribution of phenomenology and psychology to each other has been acknowledged for many years, and the contribution of phenomenology to environmental psychology and design has been noted as it provides insight into what one's experience and perception are like for the subject from its first-person point of view (Seamon, 1982). In addition, there has been renewed interest in phenomenology research increasingly found in cognitive neuroscience, as researchers found the potential of phenomenology that can help bridge the gap between mind and brain (Albertazzi, 2021), which may also help explain the interrelationship body, mind, space, and time.

To further discuss the abovementioned issues, this article integrates the concepts of synesthesia and kinesthesia into the various discourses around the body and spatial perception and perspectives on body- and sensory-based design thinking. Poulsen and Thøgersen (2011) found the essence of design thinking as "reframing" through understanding and establishing concepts and meaning. This article will analyze and discuss how consideration of the kinesthetic or synesthetic body can challenge the existing models of perception adopted in design disciplines and deepen and enrich the way of design thinking and application. Finally, this article will propose new frameworks for design thinking that concern the body experiencing a space created.

PERSPECTIVE ON BODY, SENSES, AND PERCEPTION

The link between phenomenology, environmental psychology, and design has been addressed in various notions of architecture, body, the senses, and perception (Seamon, 1982, 2015; Pallasmaa, 2005; Zumthor, 2010). Phenomenology is the study of conscious experience, which has primarily concerned itself with phenomena of vision (Milner and Goodale, 1995, p. 13; Albertazzi, 2013, p. 5) and continuously inspired research on human experiences in various domains, especially perceptual experience and embodiment in environmental design disciplines. Phenomenology seeks the *essence* of lived experience, presupposing that human experience is *intentional*; our knowledge comes from what we experience; the essential meaning of our experience is hidden (Van Manen, 1997; Franzini, 2015; Seamon, 2015). Edmund Husserl is credited with initiating phenomenology as a discipline that seeks the essence of lived experience in the "lifeworld"—the day-to-day world where one's ordinary pursuit takes place (Seamon, 2000).

The close relationship between phenomenology and built environments as well as other creative realms has been addressed by many phenomenologists, including Heidegger, Merleau-Ponty, Casey, Dewey, and Ihde. Particularly, the stance of existential phenomenology is that the lifeworld inevitably engages the body with the lived context. The construct of human existence comprises four existentials—spatiality, corporeality, temporality, and relationality (Merleau-Ponty, 2014)—in a communicative relationship with the lifeworld constructed of lived space, lived body, lived time, and lived others (Van Manen, 1997); the four existentials play an essential role in embodiment. Embodiment refers to the tangible or visible form of perceived concept and meaning through which ordinary life is incorporated into the body and becomes naturalized in the form of space (Attfield, 2000). An embodied space is imbued with one's own memories, imaginations, and dreams accumulated through the personal and/or collective experience of the space, which fundamentally involves the body and movement, whether actual or conceptual (Cresswell, 2004). Considered "experience" is from an embodied position (Ihde, 2012). Lived experience occurs in the intersubjective space of perception and the body, located between subject and object (Simonsen, 2005; Merleau-Ponty, 2014). The lived human existence is a complex, multidimensional relationship and continuous dialogue with the external world and the self. In it, every essential experience and aesthetic judgment arises in connection with a contextual whole called "situation" (Dewey, 1998); thus, there are no inherent aesthetics of objects, buildings, and spaces. Phenomenologists argue that visual appearances of things are presented with meaning, given by their qualitative characteristics such as size, scale, proportion, and reciprocal positions; meaning is the content of experience, "not semantic content but rather the intuitive coherence things have for us when we find them and cope with them in our practical circumstances" (Carman, 2014, p. x); the meaning enhances the subject's experience of the visual (Lu et al., 2011; Albertazzi, 2013).

The spatiality of the lived body is discussed in phenomenological discourses of embodied space: the personal, physical experience of space, *muscular consciousness* (Massey, 2006); spatial embodiment as "the form of inner sense [and] contains compressed time" (Casey, 1997, p. 289); a place to which one is emotionally attached, as a series of places with own memories, imaginings, and dreams (Bachelard, 1964; Cresswell, 2004). The phenomenological concept of embodiment does not account for a distinction between "being" and "having a body" and between "feeling" and "perceiving" (Sheets-Johnstone, 2019). Embodied space is not a mere collection of rooms and things but one's embodied self that inhabited the space over time; space is incorporated into the body and can be naturalized in embodiment; thus, the embodied self is central to the lived space. Spatial experience is through sensing, the means and fundamental of being (Merleau-Ponty, 2014). It involves material practice in various modes, through which people conceptualize space and time and in which they apply the concepts (Harvey, 1989) contingent upon the lived state of one's mind and body that occupy the space and perceive and act upon the setting (Bechtel and Churchman, 2003; Graumann, 2002; Pallasmaa, 2005). Together, the senses, mind, and body are integral to the total experience, so are ideas and objects.

Rooted in spatiotemporal and kinesthetic reality is the existence of the lived body comprised of continuous felt experiences, not simply its physical presence (Merleau-Ponty, 2014; Sheets-Johnstone, 2019). Merleau-Ponty's phenomenology of perception (2014) emphasizes the subjective sensory processes of the lived body, "being a self of movement" or "feeling of doing," tie the three aspects of lived body—felt, experienced, and sensed body. This work influenced proposal of Casey (1997) that the body is fundamental to place and exists in three modes—staying in, moving within, and moving between places. Merleau-Ponty also suggested that the body itself is expression that is simultaneously constituted with thought: like connotative language, the body is "a general system of symbols" that does not presuppose but rather accomplishes thought. For him, a human is a "sensorium commune" whose body accesses the world through the senses; perception of space is not a mere collection of perceptions of objects but a "flow of experiences" that expresses the spatiality of the human being.

One's perception of the external world and its own body is based on "the integration of sensory information conveyed by different modalities each weighted according to their contextual reliability" (Ponzo et al., 2018, p. 311). Sensing is the experience of a modality of the body while the senses communicate through the body (Carman, 1999, 2014); while sensation is partial, the senses "distinct yet indiscernible, like monocular images in binocular vision" (Merleau-Ponty, 2014, p. 239), are united through the body forming a perception. Thus, neither sensing nor perception can fully be understood when the world is (mis)taken "as ready-made or as the milieu of every possible event and treats perception as one of these events" (Merleau-Ponty, 2014, p. 214).

Action and Perception

In the traditional definitions, sensation, perception, and cognition are viewed as distinct phases in acquiring and processing

information: the sensory organs gather stimuli in the sensation phase; in perception—the first phase in the thought process—the brain interprets sensations and organizes the information into patterns; the second phase of the thought process is cognition, "the way the information and knowledge come to be known, through the actions of perception, reasoning, or intuition" (Kopec, 2012, p. 51). Research has shown various perspectives on environmental perception. One of them is that visual perception is dominant when people acquire and process information from their surroundings: people derive as much of their perception of distance and movement from visual cues within a space despite sometimes conflicting non-visual cues (Axelrod, 1973; Harris et al., 2000; Kopec, 2012); consequently, they become less aware of movement within a space or senses responding to other corporeal aspects if there is an abundance of visual information (O'Regan and Noë, 2001; Hurley and Noë, 2003; Sun et al., 2004). More recent studies have stressed that action and perception attribute, in tandem, to making sense of the context and content of space: action and perception are embedded in each other and bound to one's physical body and body awareness (Garner, 2018). One's bodily states provide judgments and perceptions, and sensorimotor stimulations influence those judgments made (Brouillet et al., 2010; Ionta et al., 2011). Research on perception and cognition has adopted sensorimotor approaches (Hurley, 1998; Torrents et al., 2013), embracing the phenomenological concept of embodiment (Albertazzi, 2013, p. 5).

In the 18th century, the relationship between action and perception became an interest of philosophers and psychologists, including Berkeley. He initially proposed that vision was to be determined by visual depth cues, the movement of one's eyes, with the adaptation of lens and when paired with touch would allow for people to move and interact with space and objects and therefore develop a "perception of the sensation" (Berkeley, 2008). In 20th century, action-based perception evolved from initially focusing on the movement of one's eye to inform their spatial experience and perception and moved to be thought of as enactive: sight depends on one's "sensory effects of movement" through a two-step process: users must experience the sensory stimuli and then use the sensory stimuli to retrieve sensorimotor contingencies associated with that object based on past experiences (O'Regan and Noë, 2001; Noë, 2010, p. 249). The concepts of embodiment and embodied cognition stress the mind (brain)–body connection in perception and cognition and gives attention to the impact of the interaction between the sensorimotor aspects of body and physical environments (Brouillet et al., 2010). Theories such as the motor component theory (Shebilske, 1984, 1987; Ebenholtz, 2002; Helmholtz, 2005) and the efferent readiness theories, modest readiness theory, and bold readiness theory (Coren, 1986) emerged stating that one's ability to process stimulus information is optimized by the input of additional information to aid the visual information, specifically looking at proprioceptive feedback and actions such as turning around or turning upside down affect one's understanding of the surrounding environment and objects within it. The embodied aspects of sensorimotor activities in human learning, knowing, and reasoning have been studied in education, including child learning and STEM education (Abrahamson and Bakker, 2016; Tversky, 2019). Linguistics brings to light the relationship between action and perception and linguistic responses that abstract concepts are grounded metaphorically in embodied and situated knowledge (Brouillet et al., 2010, p. 312). Studies in robotics and interactive product design also focus on somatosensory phenomena (Van Rompay and Ludden, 2015; Shima and Sato, 2017), as the action and perception of objects or space take a significant role in one's experience (Noë and Noë, 2004; Brouillet et al., 2010).

Kinesthetic Perception

Perception and cognition can be influenced by various factors such as type and intensity of stimuli, personal past experiences, current emotional state, or individuals' physiological sensitivity. One's perception of its environment, including objects, is in direct relation with its kinesthetic dimensions; the perception and the kinesthetic dimensions together create the meaning for the said environment or objects for the individual (Husserl, 1970; Gallagher and Zahavi, 2012). British neurologist Henry Charlton Bastian is credited with creating the term, kinesthesia. Kinesthesia is defined in various studies concerning bodily experiences: humans' ability to sense one's muscular movement from the lived body, the self-conscious subject perceiving its own body as the object experiencing and relating it to the environment or objects outside of the lived body encountered; the movements of the body and the kinetic sensations allow one to perceive and understand the space and objects within the environment it is inhabiting (Garner, 2018); a direct sensitivity to movement through internally mediated neuro-muscular systems (Sheets-Johnstone, 2019, p. 145). Humans possess a kinesthetic sense, affording them the ability to gain awareness of their body's location and position in relation to their surroundings. Kinesthesia belongs to the lived body, as it represents the dynamism of embodied self-experience inside of the kinetic body (Garner, 2018, p. 146). The kinesthetic sense is beyond what they see, hear, and touch; it is a form of physical holistic (i.e., neurological transmission, motion, vision, and touch/tactile), aiding in an intuitive and instinctual recognition of the characteristic of a physical location. Kinesthetic intelligence is created through the lived body sensing movement expressed and experienced. Kinesthetic intelligence and awareness enable humans to better perceive the world and cope with it; by moving in the context, one can gain access to the meaning it has to the lived body (Melcón et al., 2017; Meglin et al., 2018; Korik et al., 2019). While Sheets-Johnstone (2019) defines kinesthesia as "the evolutionary descendant of proprioception" and Garner (2018) argues that, although similar in meaning, the term proprioception is often misused when conceptually describing kinesthesia: although kinesthesia may be explained with an emphasis on its proprioceptive aspects, it is not a favored term among the literature and certain disciplines concerning movement in spatial embodiment and perception.

Kinesthetic experience is contextual and relational. In kinesthetic experience (**Figure 1**), the spatiotemporality of the lived body actualizes the articulation of sensory phenomena (Merleau-Ponty, 2014). For example, a tactile phenomenon

disappears if any of the two, spatiality or temporality, is removed: "smoothness [or roughness] is the manner in which a surface makes use of the time of our tactile exploration or modulates the movement of our hand" (p. 329). As such, body movement involves tactile qualities that help individuals comprehend their surroundings. Insight into the senses in aesthetic experience of Franzini (2011) helps explain the invisible dimension of spatial experience:

> The senses are essential to our understanding of form, but paradoxically the sensory form stands beyond what our senses can apprehend (p. 115) … [T]ouch is the sense that escapes isolation and opens to the totality of the aesthetic experience. It is an embodied perception, which goes beyond the clarity of "visibility" to include also the hidden power behind the apparent transparency of the representation. Touch indicates the possibility of reaping the hidden aspects of form, the invisible, the "unfinished" that…has been the response to the exclusively narrative, metaphorical or rhetorical view of art. In this way, one can affirm that touch is an ulterior method of opening the symbolic dimension of art, which is precluded…by its reduction to language or to only one of the senses. … [T]ouch… is bound to the ambiguity of a bodily gesture [and] is irreconcilable with any form of allegory or rhetoric (pp. 123–124).

Body movement (not a mere shift of locations or positions) in space is the foundation of one's senses, and the kinematics of its movement is modified upon the relational context of the experience. The kinesthetic sense gives humans the ability to identify specific environmental characteristics and qualities and thus enhances the spatial experience (e.g., Cutts et al., 2019; Giroux et al., 2019). It is a high level of perception that involves the complex constitution of body schema, the representation of the body's spatial properties, including exteroception, interoception, and proprioception (Valenzuela-Moguillansky et al., 2017).

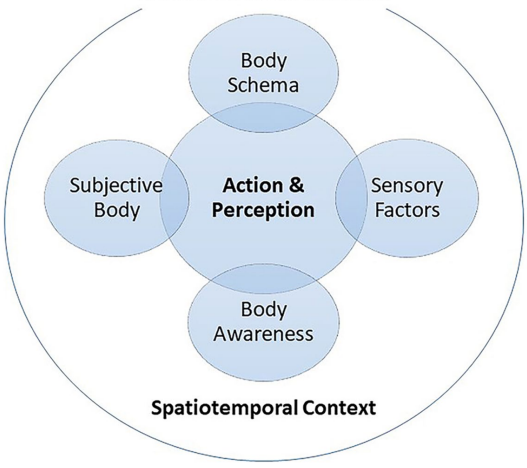

FIGURE 1 | Construct of kinesthetic experience.

In the subjective human–environment dialogue, somatosensory factors such as orientation, position, temperature, texture, and pressure also play a significant role, impacting the felt body, conscious movement, bodily boundaries, and the peripersonal space (Pasqualini et al., 2013). The pavilion *Incidental Space*, designed by Christian Kerez, provides a distinctive kinesthetic experience that involves spatial awareness, positioning of one's body, and/or perception of its movement acquired through physical sensations (**Figure 2**). The kinematics of individuals' body movements responds to the spatial context: for example, as one attempts to reach higher than its height, passes through a narrow space, or passes by another person in close proximity. Such movements are also owing to the tactile and visual texture of the material as well as the sound and echo enhanced by the cave-like form of the inner space. These auditory, tactile, and visual factors together form the total experience of the space, contributing to the spatial identity and meaning visitors establish.

Spatiotemporality and kinesthetic perception are integral to each other. While Ando's definition of space as "a place for many senses: sight, sound, touch, and the unaccountable things that happen in-between" points to the synesthetic dimension of sensory experience (Auping and Ando, 2002, p. 31), his work, including the Garden of Fine Arts (**Figure 3**) in Kyoto, Japan, often engages visitors in a kinesthetic journey throughout their experience in the settings. The spatial experience is enriched with the sensorial communication between the body and the environment: as one navigates the outdoor gallery, the sequence and gradual changes of the sound and the moist air from the cascades and the water features built around the elongated ramps comes into the total experience; the natural light and shadows change every moment while the navigating body communicates with the space in its motion and movement. No single moment is like another in the lived experience, and no single sense responds to the environment by itself; the spatiotemporality of the phenomena is the key to the total experience.

Synesthetic Perception

Synesthesia is a physio-psychological and cross-modal sensory phenomenon that is autonomous, involuntary, and irrepressible; it occurs when a stimulus in one sense modality immediately evokes sensations in one or more different sense modalities (Hubbard and Ramachandran, 2005; Van Campen, 2008; Merter, 2017). Synesthetes may see sounds, smell words, touch tastes, or taste letters, for example (van Leeuwen et al., 2016). When grapheme–color synesthetes see a number or a letter, they see a color at the same time (**Figure 4**), which is different from just imagining the color or making an association based upon memory (Ramachandran and Hubbard, 2003).

Due to the lack of information in the past, synesthesia was sometimes misunderstood as a neurological disorder, a brain impairment, or even a mental illness. However, there has been general appreciation for the synesthetic representation of artistic ideas found in many artists' works, including that of Vincent

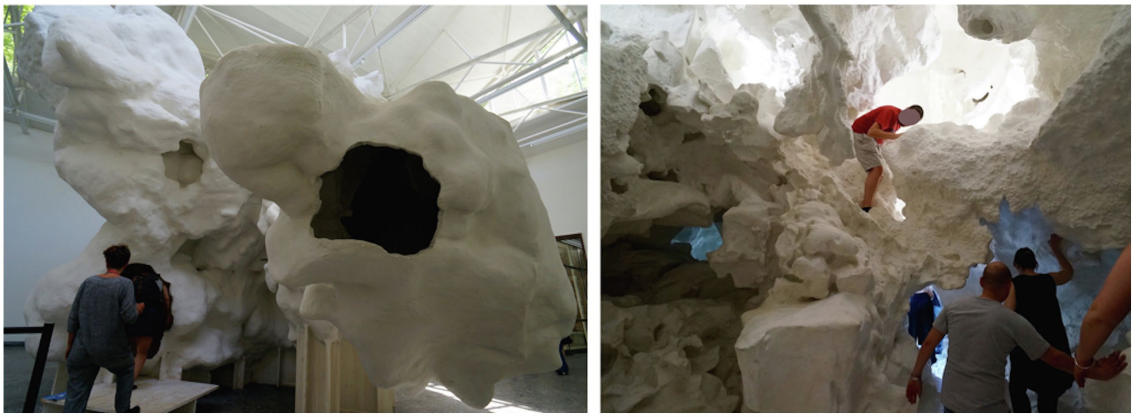

FIGURE 2 | Pavilion *Incidental Space*, Christian Kerez, Venice Architecture Biennale 2016, Venice, Italy. Photo credit: Jain Kwon.

FIGURE 3 | Outdoor gallery viewed from the lower level (left) and a cascade viewed from an elongated ramp (right). Garden of Fine Arts, Tadao Ando, Kyoto, Japan. Photo credit: Jain Kwon.

van Gogh, Wassily Kandinsky, and Piet Mondrian (Ione and Tyler, 2003; Schneck et al., 2006; Van Campen, 2011; Melcher and Zampini, 2011). Kandinsky (1982) described his experience of listening to Wagner: "*I saw all my colors in my mind; they stood out before my eyes. Wild, almost crazy lines were sketched in front of me*" (p. 364). He also gave many of his painting's musical titles, for example, *Compositions VII*, as if they were visible music. Nabokov (1989), in his *Speak, Memory*, described his grapheme–color synesthesia (e.g., **Figure 4**): "the long *a* of English alphabet […] has for me the tint of weathered wood, but a French *a* evokes polished ebony" (chapter 2, para. 2). The literature has also shown synesthetic metaphors such as "architecture as frozen music" by Goethe and "poetry of light" by Louis Kahn. The Renaissance architect Alberti described his synesthetic interpretation of architecture: "music and geometry are fundamentally one and the same; […] music is geometry translated into sound. […] In music, the very same harmonies are audible which inform the geometry of the building" (in Wittkower, 1971, p. 9). Synesthetic metaphors have also appeared in design research on human experience even though the studies do not explicitly address synesthesia, the sensory phenomenon. For example, whether intended or inadvertent, the semantic differential of connotative terms used in qualitative studies in the field often has synesthetic implications: tactile terms (e.g., hot–cold, rough–soft, and heavy–light) are used as semantic differential scale anchors to measure participants' responses to visual stimuli; ambivalent terms (e.g., light, soft, high, dull, and sharp) are used for representing various sensory ideas such as visual, tactile, and aural (Madden et al., 2000; Yoon, 2008; Kwon and Kim, 2021).

The phenomenological perspective on subjective sensory experiences is explained often with reference to *quale* (plural *qualia*): a consciousness like an introspectively accessible "region" where variable modalities of sensing take place and, together,

FIGURE 4 | Example of a grapheme-color alphabet.

come into perception (Van Campen, 2008). However, Merleau-Ponty (2014) pointed out the traditional concept of *quale* (plural "qualia") does not properly explain certain sensory phenomena such as synesthesia:

> … synesthesia [cannot be explained, for example,] if vision is defined by the visual *quale*, or sound by the sonorous *quale* … [It is not] merely that has a sound and a color at the same time: it is the sound itself that [one] sees, at the place where colors form. This formulation is literally rendered meaningless if vision is defined by the visual quale, or sound by the sonorous quale. But it falls to us to construct our definitions in such a way as to find a sense for this experience, since the vision of sound and the hearing of colors exist as phenomena. … if we do not notice [synesthesia], this is because scientific knowledge displaces experience and we have unlearned seeing, hearing, and sensing in general in order to deduce what we ought to see, hear, or sense from our bodily organization and from the world as it is conceived by the physicist (pp. 237–238).

Merleau-Ponty's stance on synesthetic perception is that human perception unites all sensory experiences into a single lifeworld, and thus the "total experience" of things is through our embodied senses:

> The vision of sounds or the hearing of colors comes about in the same way as the unity of the gaze through the two eyes, insofar as my body is not a sum of juxtaposed organs, but a synergetic system of which all of the functions are taken up and tied together in the general movement of being in the world (Merleau-Ponty, 2014, p. 243).

Interpretation of Chumley (2017) of *quale* may support Merleau-Ponty's stance by referring to sensing of intangible existence such as "energy" normally perceived by its relation to actualized objects across multiple sensory modalities—audible, smellable, tangible, tasteable, and visible; thus, quale needs to be viewed as what makes sense of our understanding of language or signs, which is constantly reconstructed and evolving, not as a stable system. In the same vein, Franzini (2011) suggests that "the specificity of the [senses] involved in the act of perception is always within a communicative context in which synesthetic perception is the rule" (p. 125). As the cross-modality of synesthesia has increasingly been discovered, studies have re-conceptualized and redefined synesthesia and proposed alternatives severing the exclusively sensory interpretation of synesthesia: synesthesia is a semantically induced phenomenon that involves high-level cognitive representation (Ward et al., 2007; Mroczko-Wąsowicz and Nikolić, 2014). Such propositions may encourage reconsideration of the traditional distinction between perception and cognition assumed for a long time in philosophy, psychology, and cognitive science (Mroczko-Wąsowicz and Nikolić, 2014).

Synesthesia is certainly not a skill or knowledge (to be figured out, so to speak) nor what everybody experiences. There have been attempts to conceptualize synesthesia in an easier way by determining the construct of the unique phenomenon: for example, synesthesia consists of a perceptive phenomenon, metaphor, and representation; features such as color or sound (qualitative) relate to subjective values; features such as image size or sound intensity (quantitative) relate to intersubjective values (Riccò et al., 2003). Such categorization may need careful interpretation, as some readers might misunderstand it as if synesthesia is some type of sensory association or imagination. From a designer's perspective, the interpretations of synesthesia in the literature—for example, a secret sense, the sixth sense (Sherrington, 1906), a hidden sense, or "everyday fantasia" (Van Campen, 2008)—have an important implication: understanding the cross-modality of the senses may help designers establish a new mode of creative thinking and diverse perspectives on sensory phenomena and spatial experiences.

BODY AND THE SENSES IN DESIGN THINKING

Design thinking methods in which designers' empathy plays a role have encouraged the processes of understanding others (i.e., occupants or users), which is a matter of interpretation of mind and body (Plank et al., 2021) and attention to verbal and non-verbal, visual and non-visual, or tangible and intangible cues within the context. Kinesthetic and synesthetic concepts are not always clearly distinguishable from each other. Movement by (and through) the mindful body is foundational to our understandings of human experience (Sheets-Johnstone, 2019, p. 25). The mindful body is kinesthetically informed and can be synesthetically conceptualized—as no single sense can work by itself separately from the others. Because the mindful body is contextual and relational, individuals perceive and conceive space differently, which is affected by their own life experiences (Cialone et al., 2017) and other people in direct or indirect interaction with them. On the one hand, interior designers' life experiences help them establish strong insights into design decisions and the design process. On the other

hand, those experiences might dominate their conceptions of human experience and result in them relying on their self-reflection overlooking the perspectives of interior occupants despite that it is one of the most critical and challenging tasks of designers.

This paper proposes three design thinking models, suggesting that the design exploration incorporating the concepts of kinesthetic and synesthetic perceptions can foster diverse perspectives on occupant spatial experiences resonating with the environments. The cross-sensory concept of synesthesia and the corporeal and spatiotemporal aspects of kinesthesia are integrated into the three models for design thinking: synesthetic translation (**Figure 5**), kinesthetic resonance (**Figure 6**), and kinesthetic engagement (**Figure 7**). The processes of the three models include designer (*self*) and participants (*other*) in synesthetic or kinesthetic experiments to varying degrees. The three approaches were developed as pedagogical frameworks for an entry-level interior design studio course focused on collaborative design thinking and processes engaging participants with no design background.

Synesthetic Translation Model

Visualizing abstract ideas and transferring them into spatial configuration is a conceptually translational process. The Synesthetic Translation Model (**Figure 5**) involves a participant's (*other*) narrative of an auditory (e.g., musical) experience, designers' (*self*) synesthetic interpretation of the non-visual and intangible sensory properties and qualities the participant describes, and the designers' self-experience and reflection of the interactive context and event with the individual. The *self* and *other* can be single persons or groups depending on the project. This model shares some aspects of narrative design methods. While narrative methods have often been used to promote designers' imagination in design thinking, the research raised a concern that using narrative methods may interfere with the visual representation of their imaginations and ideas (Danko et al., 2006). It is important to note that synesthetic phenomena are fundamentally lived, so they differ from imaginations or memory-based sensory associations. The design approach must concern the lived nature of occupant experiences. The synesthetic translation model emphasizes designers' empathetic approach as reflection—not imagination—of participants' lived experience.

An example of synesthetic translation design thinking uses music as a non-visual inspiration (*sensory stimuli*) and involves a participant representing *the body* (*other*) as a subject of sensory experience as well as an object the designers perceive in the interactive event and the spatiotemporal context. This approach focuses on the audiovisual and temporal realms of the participant's musical experience and designers' synesthetic interpretation of the participant's narrative in the lived context and "translation" of the verbal description into a spatial setting. The synesthetic translation approach consists of five phases: (1) music plays as a sensory stimulus, (2) music replays during the participant's concurrent think-aloud (narrative), (3) designers' interpretation of the participant narrative, (4) visualization of the essences of participant experience, and (5) spatial configuration and prototyping. The participant's concurrent narrative in this process can provide "vivid" descriptions of the lived experience, possibly implying the concept of multisensory and cross-sensory phenomena. Although music is typically described as an auditory phenomenon, it is, in fact, multimodal. For example, music engages the body with its vibrations, volumes, and cadences that rise and fall, increase and decrease, and quicken and slow (Garner, 2018, p. 172). The properties of sound (music), for example, intensity, volume, pitch, and rhythm, are closely linked to the concepts of spatial attributes such as compression/expansion, volume, scale, and pattern. Indeed, they are described in similar words, for example, heavy–light, strong–soft, rough–smooth, and dark–bright. Musical experience needs to be explained in spatial terms because music is the sounds ordered in time, which moves through the imaginary space of music (Scruton, 2004). The concept of movement is metaphorically applied to creating the sequence of space, in which designers' interpretation of sensory experience and "synesthetic intelligence" play the key role. Due to the attention to the temporality of musical experience that is fundamentally sequential, the designs produced applying the synesthetic translation model tend to show linear (or spiral) progress or "journey" in the spatial configurations (Kwon, 2017, p. 390). Thus, this model may be adopted in design processes where storytelling is the key.

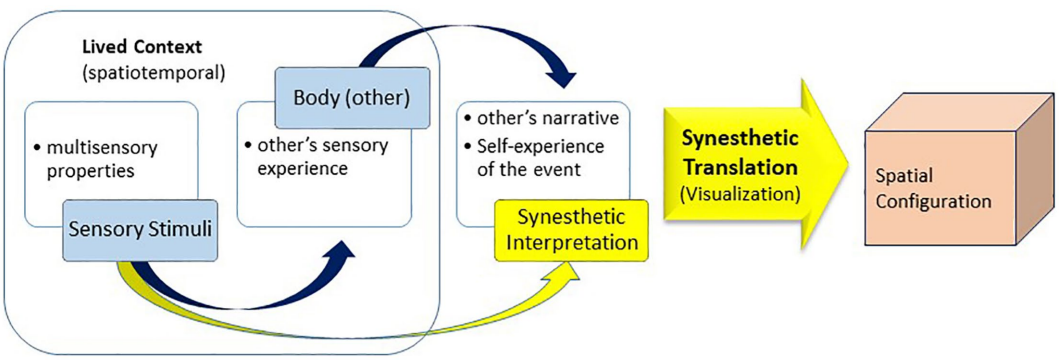

FIGURE 5 | Synesthetic translation model for design thinking.

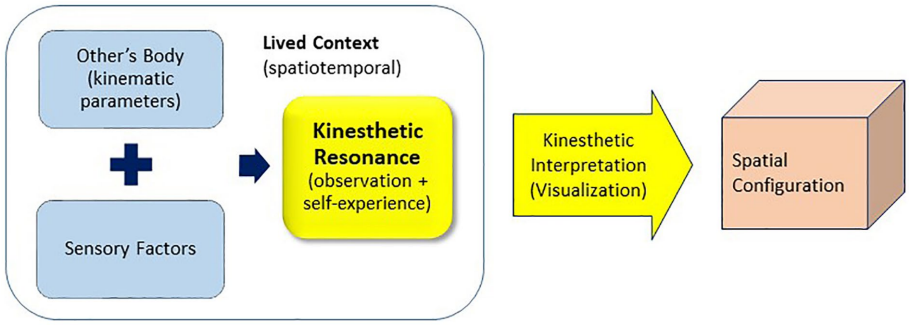

FIGURE 6 | Kinesthetic resonance model for design thinking.

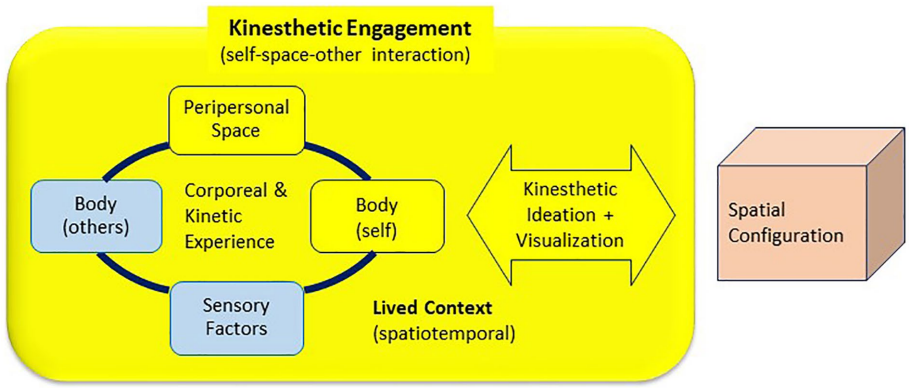

FIGURE 7 | Kinesthetic engagement model for design thinking.

Kinesthetic Resonance Model

Humans recognize and respond to their surroundings and other entities in the context, including others' bodies and their kinematic parameters (Torrents et al., 2013; Garner, 2018). Individuals use their knowledge of their bodies and current and previous situations to understand abstract concepts (Lakoff and Johnson, 1999). The Kinesthetic Resonance Model (**Figure 6**) integrates the kinematic parameters of others (e.g., inspirational art performers, prospective occupants/users, and passers-by) observed by an audience (i.e., designers) into design thinking. Kinesthetic resonance refers to "the perceiving subject's vicarious engagement with the movements of others"; the responses are situational, multi-directional, and variable (Garner, 2018, p. 145). In the perception of another's intentional action, what we know about movement has an impact on the sense of engagement we experience and the vicarious engagement we feel in our muscles (Garner, 2018, p. 158). Empirical studies in performing arts have shown the relationship between kinesthetic and expressive qualities that reveal the emotion represented in the work of arts (Montero, 2012; Garner, 2018). Certain kinematic parameters in dance influence a non-expert audience's aesthetic perception of the artistic expressions of movement (Torrents et al., 2013, p. 457). In one's aesthetic experience in a constructed environment, empathy plays a role in its resonance with the space and as activation of embodied mechanisms (Freedberg and Gallese, 2007; Jelić et al., 2016).

Attfield (2000) found dance and music as useful tools for explaining a sense of movement in relation to space and time: innately, dance, music, and space are present in time, which is a channel through which human existence represents a sense of temporality and continuity. Seamon (1980) has used the metaphor of dance and "time–space routines" to characterize the sequences of actions that make up everyday practices (Cresswell, 2004). Thus, dance can be used as an inspirational tool in design exploration based on designers' observation of movements (e.g., amplitude, turning velocity, balance duration, jump height, and range of motion) and their experience of the event in relation to the spatial setting and other circumstances. Dancers' movements not only show the postures and positions of their bodies but also convey the dynamics that affect the audience's kinesthetic resonance: kinetic energy and human–human and human–environment interactions—for example, dancer–dancer, dancers–audience, dancers–space, dancers–music, and audience–music—in the space and time.

The kinesthetic resonance approach illustrated in **Figure 6** is inspired by (not direct reflection of) the phenomenological concept of John Cage's composition 4′ 33″ that uses an "expressive silence" as a means of engaging the audience in the abstract dialogue during the piano performance: while a pianist is sitting

at the piano for 4 min and 33 s, no piano music is played. Some people might view the "performance" as plain silence beside the random sounds the audience makes (e.g., rustling and creaking noises from people shifting in their seats and coughing) because the performance does not convey a particular musical intention. Yet, the pianist still "performs," creating the "expressive silence" that embraces the unpredictable and lived event (Cage and Gann, 2011). The audience is contributing to the performance by being part of the lived context, observing the performers (and perhaps the others in the audience), and reacting to the circumstance in which the audience's kinesthetic resonance takes place.

When the kinesthetic resonance approach is adopted in exploratory design projects engaging professional dancers and music, it often results in outcomes that the envelope—rather than the space inside—of the designed space tends to be representational of the concept and resemble the visual of the dancers' body postures in a captured moment or rotational movement. It may be because the approach heavily relies on the designers' observation. This model may better suit the conceptual visualization of an observed scene or designing an object or relatively small structure (e.g., fixture, pop-up kiosk, and three-dimensional artwork) that the view from the outside is one of the primary interests in the design process.

Kinesthetic Engagement Model

Spatial perception is reciprocal with self-consciousness: the sense of agency, sense of body ownership, and self-location (Longo et al., 2008; Pasqualini et al., 2013; Galvan Debarba et al., 2017). In other words, spatial perception occurs through the embodiment of the material properties of the environment (Gibson, 1979; Blanke and Metzinger, 2009); the sense of embodiment emerges from the feeling of motor control over one's own body perceived in its location. The content of spatial experience is enacted by action engaging the body and its sensory mechanism (Noë and Noë, 2004), to which kinesthetic perception is key.

Corporeal concepts originate in the context of moving (action) and thinking in movement (Sheets-Johnstone, 2019). Embodied design approach foregrounding the kinesthetic sense is an important design strategy in which how moving and knowing bodies can impact the way designers think and work (Wilde et al., 2011; Loke and Robertson, 2013; Kwon, 2018, 2020). The Kinesthetic Engagement Model (**Figure 7**) represents action-based design thinking and the embodied processes through human–human and human–space interactions. The interactions are enacted by the actors—the self (designers) and others—engaged in bodily movements and conceptualizing the movements in relation to the space and time in which the movements take place.

Movement-based approaches can foster the connection with emotion and bodily sensations in sensorimotor processing, establishing coherent body awareness and gaining familiarity with bodily sensations as part of embodied subjectivity (Valenzuela-Moguillansky et al., 2017). The project illustrated in **Figures 8, 9** used the kinesthetic engagement model focused on occupant bodily engagement and experience in a setting. The design process included experiments (**Figure 8**) focused on how physical bodies—the self's and other's—could create the sense of space, territory, or boundary, responding to the surrounding. For the project, interior design students played dual roles, occupants (users) and designers, to learn occupant experience from the first-person point of view and incorporate it in their designs. Students "choreographed" the dialogue between their own bodies and space, conceptualizing the gestures, movements, positions, and postures: for example, balance, stability, tension, fluidity, and containment often discussed in design disciplines. This experiment was followed by ideation conveying the concepts of the body and movement in a confined space (**Figure 8**). Finally, students designed and built full-scale structures of experiential space (**Figure 9**), portraying their sensorimotor and somatosensory experiences through their bodily exploration.

One's kinesthetic intelligence is affected by the felt scale of its own body and relationship with the spatial setting. Prototyping (except for study mock-up) in the kinesthetic engagement approach was conducted on a 1:1 scale. The outcomes through the three approaches—synesthetic translation, kinesthetic resonance, and kinesthetic engagement—with designers' bodily engagement to varying degrees, showed interesting patterns in design outcomes (**Table 1**): (1) designs using the synesthetic translation model presented sequential order of space; (2) many outcomes through the kinesthetic resonance approach appeared in spiral configuration and the exterior form reflected body posture captured in a specific moment of the total movement; (3) designs through the kinesthetic engagement processes showed their emphases on the interior configuration and space, the negative form of which resembled and evoked various body movements.

DISCUSSION

Based on the conceptual and theoretical analysis of synesthetic and kinesthetic perceptions, this article proposed three design thinking models: the synesthetic translation and kinesthetic resonance models are based on designers' descriptive reflection through listening and observing; the kinesthetic engagement model emphasizes designers' bodily engagement and interaction with others and the space. Engaging the body, senses, and movement in design thinking can help determine the relationship between the designed environments and the end-users. Design thinking is fundamentally embodied and, like perception, innately lived; it differs from memory-oriented associations or imaginations in which the body is dislocated from time and space (Hubbard and Ramachandran, 2005). Spatial experience involves the subjective, multimodal, and contextual body and sensorimotor phenomena; bound in time is an active (non-linear) process of establishing meaning based on one's awareness and understanding of the self, others, and its surroundings. Embodied design approach that is requisite for the creation of meaningful space cannot be reduced to a linear process of ideation, analysis, and synthesis clearly separated. Designing is an embodied process through being

FIGURE 8 | Kinesthetic design process engaging the body: bodily experiment and ideation. Photo credit: Jain Kwon.

FIGURE 9 | Full-scale prototyping. Photo credit: Jain Kwon.

TABLE 1 | Construct of three design thinking models: synesthetic translation, kinesthetic resonance, and kinesthetic engagement.

	Synesthetic translation	**Kinesthetic resonance**	**Kinesthetic engagement**
Perceptual Emphasis	Synesthetic (cross-modal)	Kinematic	Kinesthetic
Sensory Stimuli	Auditory: Music	Auditory + Visual: Music & Dance	Auditory + Visual + Haptic: Bodily Experiment
Perspective on occupant experience	Reflective	Observational	Experiential
Emphases in design approach	• Empathy in Aesthetic Experience • Understanding Others' Sensory Experience	• Embodied Space • Observation and Interpretation of Movement in Spatiotemporal Context	• Embodied Design Process through Bodily Engagement
Designer's key role in experiment	Interpreter	Observer & Interpreter	Actor
Design emphasis	Descriptive reflection of other's narrative	Observation and descriptive reflection of human–human and human–space interactions	Use of own body to determine forms and the scale in ideation
Tendencies found in design outcomes	• Representative of a "journey": linear configurations & perpendicularly sequential order of occupant experience • Designed space in "monument" scale • Reflection of emotional feelings	• Reflection of captured moments and the scenes: circular, spiral, curvilinear configurations • Vertically sequential order of occupant experience • Designed space in human scale • Visual description of the kinematic parameters of others' bodies	• Reflection of body movements, postures, bodily interactions with others, and physical settings • Non-linear; multiaxial • Designed space in human scale • Description of body movement and kinesthetic responses

a self of movement and feeling of doing, which is perceptual, perceptive, and expressive. The concepts of body awareness, sensory experience, and spatial perception are increasingly diversified, especially with emerging technologies, including mixed reality and motion-sensing. Constructed—whether physical or virtual—environments are experienced through the presence of its occupant being a self of movement or feeling of doing that ties felt/feeling, experienced/experiencing, and sensed/sensing body together. Some of the sensory responses of the body are seldom integrated into design thinking and yet to be explored, for example, synesthetic and phantom sensations—caused by immersion in VR environments.

This article suggests that abstract conceptualization and bodily engagement are not entirely separate processes in design and stresses that spatial perception is fundamentally experiential and lived, neither imaginary nor assumptive. Design approaches that integrate kinesthetic and synesthetic experiences and perceptions anchored in the lived body can help enhance designers' understanding and incorporation of aesthetic sensibility—how people perceive and appreciate sensory phenomena—and mind–body connectivity in design thinking. Design disciplines may reexamine the traditional concepts of perception and cognition as separate phases of information processing through the sensory system. This article discussed how consideration of the kinesthetic or synesthetic body and phenomena could deepen and challenge the existing models of human perception and aspects of environmental psychology adopted in design disciplines. Looking into the integration of tangibility and intangibility into design thinking, and the strengths and weaknesses of experiential, observational, and imaginary approaches that have been adopted in design thinking may also provide provocative new insights into what the body means for designers to consider, and such efforts can contribute to the body of knowledge in environmental design disciplines.

AUTHOR CONTRIBUTIONS

JK developed the study, conducted the conceptual and theoretical analysis, developed the proposed models, and wrote the manuscript. AI, a graduate research assistant, assisted with the literature review. All authors contributed to the article and approved the submitted version.

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Evaluation of Daylight Perception Assessment Methods

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Daylight is an important component in maintaining human health and wellbeing and plays a key role in physiological, psychological, and behavioural regulation. Understanding the complexity of daylight perception is vital since the degree of satisfaction with daylight conditions could greatly impact individual mood, behaviour and cognitive performance. This paper aims at (1) presenting an overview of current knowledge on methods for assessing daylight perception and (2) establishing a methodology for assessing daylight perception in the context of cultural background. An experiment was conducted with 50 students who were instructed to select the best and worst seats, describe the best desks' daylight conditions and draw boundary lines between perceived daylit and non-daylit spaces in a library. The study showed that subjective rating and seat preference methods were consistent with actual daylight levels. However, participants' boundary lines did not represent the actual daylight availability in the space. The study suggests that individual daylight perception in the context of cultural background can be assessed using the subjective rating and seat preference methods.

Keywords: daylight availability, daylight perception, seat preference, drawing, environmental behaviour, method evaluation

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INTRODUCTION

The characteristics of an indoor lighting environment could significantly affect the comfort, wellbeing and productivity of building occupants (Al horr et al., 2016). The lighting quality assessment typically includes photometric measurements, which does not provide a complete representation of an environment's lighting quality (Allan et al., 2019). The assessment should not only consider the links between the lighting levels and the characteristics of the space where light is measured but, more importantly, how people perceive that environment. As of today, far too little attention has been paid to daylight perception and its evaluation methods, as highlighted by the Commission Internationale de l'Eclairage 2013 (CIE 213, 2014) and the Dubois et al. (2016). Understanding its complexity and potential benefits could be crucial, especially in the context of health and wellbeing, mood, and also cognitive and academic performance. Up to now, several studies have shown that exposure to different amounts and characteristics of daylight could enhance students' cognitive performance (Shishegar and Boubekri, 2016; Jamrozik et al., 2019). However, it is still not known how students' daylight perceptions and preferences and the level of daylight they are satisfied will contribute to their academic performance.

Culture, one of the essential components of an individual, delineates the characteristics of a group with similarities such as language, religion, tradition, and ethnicity. Knowing the

cultural background of a group of people is vital because it could help understand why a group of people acts similarly compared to another group. Lighting research to date has tended to focus on the impact of cultural background on glare discomfort perception rather than daylight perception and satisfaction. Most cross-cultural lighting studies have examined discomfort glare perception and colour temperature preference, but they did not sufficiently focus on the adequacy of illuminance levels. Cross-cultural studies aiming to investigate lighting preferences in interior environments are rare and what is not yet known is the importance of cultural background and its impact on daylight perception, expectation and satisfaction.

In the field of lighting environment, Pierson et al. (2018) have used the term of 'culture' as '*the climatic and indoor conditions to which the subject has been accustomed during the major part of his/her life, his/her behaviour toward this indoor environment, and his/her expectations about it*'. Subsequently, a recent study (Izmir Tunahan et al., 2021) has highlighted the importance of cultural background in daylight perception and suggested that the cultural background in the lit environment should be evaluated, considering (1) the ethnicity and/or physiological characteristics of the individual eyes, (2) the area (luminance environment) where people used to live, (3) the luminance environment they were recently exposed to, and (4) the socio-cultural background of individuals.

In the United Kingdom, students constitute 19% of higher education (equals to 438,010 students) with 13.6% of undergraduate, 36.6% of postgraduate (taught) and 43.2% of postgraduate (research) students. They travel mostly from countries with a wide range of daylight conditions that differ from each other and from daylight conditions in the United Kingdom (e.g., China, Malaysia, the United States, Nigeria, India, Germany, France, Italy and Ireland; UKCISA, 2017). Outside daylight conditions refer to the amount and duration of daylight varying with the sun's position in the sky depending on latitude and atmospheric conditions that depend on various factors (e.g., turbidity, climate and pollution). Hence, students from different parts of the world could be assumed to have previously experienced different lighting environments and students from locations with similar daylight conditions should have comparable daylight expectations. To this end, students' cultural diversity and the specific lighting environments they were previously accustomed to could affect their perception and expectation towards the outdoor and indoor conditions they found in the United Kingdom (Izmir Tunahan et al., 2021).

Maintaining the students' satisfaction with the indoor environment they found in the United Kingdom is considerable because the indoor environmental quality is highly associated with the occupants' health and wellbeing (Sakellaris et al., 2016). The degree of satisfaction, in particular with daylight conditions, greatly impacts individual mood, behaviour and cognitive performance (Wang and Boubekri, 2011). Therefore, gaining a better understanding of students' daylight perception and expectations could increase their satisfaction with the indoor environment and also cognitive and academic performance. This knowledge can also be utilised by managers and daily operators of university buildings to help reduce the energy consumption of HVAC (Heating, Ventilation, and Air Conditioning) and illumination systems. For instance, a study on Korean office buildings showed that adjusting the indoor lighting conditions based on occupants' expectations and utilisations helps to reduce lighting energy consumption by up to 43% (Yun et al., 2012). Moreover, it can support architects and lighting professionals working in the design of educational and residential buildings.

In order to maintain the satisfaction and academic performance of the students from different cultural backgrounds in the indoor environment they found in the United Kingdom, we needed to develop a methodology for assessing daylight perception. Therefore, this paper aims to (a) review the methods previously used to assess daylight perception and (b) establish a methodology for assessing daylight perception in the context of cultural background.

THE HUMAN RESPONSE TO DAYLIGHT: EVALUATION METHODS

In order to create a framework of the methodological approach to assess daylight perception in the literature, 482 research articles published in Scopus, Web of Science, and LEUKOS databases were searched for electronic records. The search was done in either title, abstract, or keywords of the papers using the following keywords: (Day)light perception, (Day)light expectation, (Day)light satisfaction, (Day)lighting sensitivity, (Day) lighting tolerance and (Day)light adaptation. The inclusion criteria were: (a) including at least one aspect of (day)lighting perception, (b) published in English, peer-reviewed journals excluding conference proceedings and books, and (c) published during any year from 1990 to November 2021. Relevant articles were classified depending on their methods and reported in **Tables 1–3**.

General Methodological Approach in the Reviewed Studies

Various methods have been developed and used to investigate how lighting conditions are consistent with human perception of daylight and daylight expectations. These methods have been applied in either real-world environments (Keskin, 2019) or laboratories under specified testing conditions (Chamilothori et al., 2016; Chinazzo et al., 2019; Yasukouchi et al., 2019).

Even though real-world environments provide an opportunity to conduct studies in a dynamic social context, people being observed cannot be tested under diverse environmental conditions. Conversely, participants in laboratory settings know they are the subject of study, which may affect their behaviour, making it challenging to associate results with real-life situations (Keskin, 2019). Nevertheless, laboratory studies enable researchers to investigate changes when daylight conditions are changed (Figueiro et al., 2011; Karami et al., 2016), which cannot be tested in real-world environment studies.

Although most methods and tools used in assessing daylight perception differ, their general methodological approach is similar; it combines subjective and objective measurements

TABLE 1 | The methods for circadian rhythm related assessment.

Method		References
Cognitive performance	**n-back test** *to measure working memory and working memory capacity*	Jaeggi and Jaeggi, 2011
	CNV test *to measure work performance with the average response times of correct answers*	Yasukouchi et al., 2019
	Arithmetic task *to reflect work performance with the ratio of correct answers*	
	Tsai Partington *to evaluate the distributed visual attention*	Chinazzo et al., 2019
	d2 test *to evaluate the sustained vigilance* **Baddeley test** *to evaluate the logical reasoning*	
	Psychomotor Vigilance Test (PVT) *including a Simple Reaction Time (SRT) test, a 2-Forced Choice Reaction Time (FCRT) test, and a Matching-to-Sample (MTS) test.*	Figueiro et al., 2011
	Observation of Typing speed and accuracy	Shamsul et al., 2013
	Eye-tracking *for measure numbers of fixation with a device such as Tobii® T60 Eye Tracker*	Shamsul et al., 2013
	Class attendance *as a measure of students' performance*	Edwards and Torcellini, 2002
Alertness	**Visual Analogue Scale (VAS)** *to assess fatigue and alertness*	Karami et al., 2016
	Karolinska Sleepiness Scale *to measure both subjective sleepiness and alertness*	Shamsul et al., 2013; Chinazzo et al., 2019
Sleeping pattern	**Subjective sleepiness** *with some surveys such as the 9-item Karolinska Sleepiness Scale (KSS) and Sleep Habits Survey*	Figueiro et al., 2011; Jaeggi and Jaeggi, 2011; Figueiro et al., 2014; Karami et al., 2016; Choi et al., 2019
	Sleep-activity behaviour	Adamsson et al., 2018
	A daily sleep-activity graph during the experiment	
	Identification of morningness-eveningness	Chung, 2009; Jaeggi and Jaeggi, 2011; Figueiro et al., 2014; Adamsson et al., 2018
	Horne and Ostberg Morningness-Eveningness Questionnaire, Munich Chronotype Questionnaire (MCTQ) and Composite Scale	
Mood	Psychosocial stress *assessing with Perceived Stress Scale (PSS)*	Figueiro et al., 2011
	Mood *assessing with the Positive and Negative Affect Schedule (PANAS), and the Centre for Epidemiologic Studies Depression Scale (CES-D*)	Figueiro et al., 2011
	Subjective general health evaluation *using GHQ questionnaire*	Karami et al., 2016
	Subjective mood and visual comfort using *visual analogue scales (VASs)*	Choi et al., 2019

and assesses them depending on the existing lighting conditions collected by either spot measurements or daylighting simulations. The studies are also often supported by circadian rhythm parameters, such as cognitive performance, alertness, sleep quality, and mood. Nevertheless, almost all studies have used one or more methods to assess the changes occurring in daylight perception concerning the variation in the luminous environment.

Methods Regarding Circadian Regulation

Circadian rhythms are approximately 24-h cycles controlled by an internal master clock in the brain responsible for regulating many physiological (body temperature and hormones) and behavioural (sleep, mood, alertness and performance) changes (Skene and Arendt, 2006). Circadian rhythms are mainly affected by the intensity and timing of light exposure (Arguelles-Prieto et al., 2019) and adjusted at regular intervals by receptors transmitting non-image-forming information of light, which activate the circadian system (Bellia et al., 2011).

Exposure to a high amount of daylight (for example, spending a large amount of time outside or sitting indoors by a big window) has been shown to be related to enhancer effects in students' cognitive and academic performance (Shishegar and Boubekri, 2016). Previous research that examined the impact of different shading systems on cognitive function performance, satisfaction, and eyestrain in a living lab has also established that satisfaction with indoor daylight conditions could result in higher cognitive performance (Jamrozik et al., 2019). Most researchers have benefitted from commonly used tests and techniques such as the Psychomotor Vigilance Test (PVT), usually used to assess the link between daylight and cognitive performance. Others have also used class attendance or typing speed and accuracy as an indicator of cognitive performance.

On the other hand, several studies have proved that daylight exposure significantly influences occupants' mood state (Boyce et al., 2003). Küller et al. (2006) indicated that the participants' mood reached the lowest level when describing the daylight conditions as too insufficient. Specified scales (PSS, PANAS, CES-D and VASs; Figueiro et al., 2011; Choi et al., 2019) and questionnaires (GHQ; Karami et al., 2016) are usually utilised to investigate the association between the exposed daylight conditions and mood states.

Changes in circadian rhythms have also been associated with sleep quality and alertness in addition to mood and cognitive performance (Garbarino et al., 2020). The Karolinska Sleepiness Scale (KSS) has been mainly used to measure both subjective sleepiness and alertness (Shamsul et al., 2013; Chinazzo et al., 2019). Tools such as the Horne and Ostberg Morningness-Eveningness Questionnaire and the Munich Chronotype Questionnaire have also been used to assess the sleep quality of participants grouped according to their sleep–wake behaviour (morningness–eveningness; Jaeggi and Jaeggi, 2011; Adamsson et al., 2018).

TABLE 2 | The methods for subjective daylight assessment.

Method		References
Interviews	*Informal or semi-structured*	Axarli and Meresi, 2008; Dianat et al., 2013; Gentile et al., 2015; Yasukouchi et al., 2019
Questionnaires	**Questionnaire-based survey** *Snapshot subjective assessments such as Perceived lighting quality assessment and other created questionnaires mainly using a semantic differential method*	Cheung and Chung, 2008; Dianat et al., 2013; Gentile et al., 2015; Adamsson et al., 2018; Bournas et al., 2019; Chamilothori, 2019; Chinazzo et al., 2019
	Questionnaire-based survey *Long term subjective assessments*	Jakubiec et al., 2018
	Subjective evaluations *during experiments within different kinds of room (geometry/orientation/ window type/façade type), different locations and different contexts (social or working context)*	Axarli and Meresi, 2008; Chamilothori et al., 2016, 2018, 2019; Bian and Luo, 2017; Jin et al., 2017
	Visual comfort evaluation *such as Visual comfort on visual analogue scales (VAS), Office Lighting Survey (OLS), Lighting Conditions Survey, NRC Canada Lighting Quality Scale, IEA retrofit monitoring user assessment survey, Indoor Environmental Quality Surveys*	Jaeggi and Jaeggi, 2011; Shamsul et al., 2013; Bian and Luo, 2017; Adamsson et al., 2018; Alicia et al., 2019
	Indoor Environmental Quality Surveys *such as Satisfaction with Environmental Features and Subjective ratings of discomfort glare (De Boer scale, Imperceptible-intolerable 4-point scale, Glare Sensation Vote, Visual comfort rating)*	Alicia et al., 2019
	Other subjective measures of lighting *Descriptive scales and Lighting preferences, beliefs, and behavioural consequences*	Alicia et al., 2019
	Verbal questionnaire *Evaluation of the impressions of how pleasant, interesting, and exciting the space*	Chamilothori et al., 2019
	Questionnaires *distributed by mail to evaluate brightness and distribution*	Bournas et al., 2019
Quantification of daylight exposure consequently circadian light exposure	**Actigraphy data from wearable biometric devices** *during the experiment with wristbands such as Empatica E4 wristband*	Figueiro et al., 2014; Chamilothori et al., 2018, 2019; Chinazzo et al., 2020
	Actigraphy data from wearable biometric devices *during the experiment with the Daysimeter*	Rea et al., 2010
	Actigraphy data from wearable biometric devices *during the experiment with the ambulatory circadian monitoring device (ACM)*	Arguelles-Prieto et al., 2019
	Actigraphy data from wearable biometric devices *prior to the study beginning, withbed and wake times with wristbands such as Actiwatch-L*	Chung, 2009;Jaeggi and Jaeggi, 2011; Yasukouchi et al., 2019
	Actigraphy data from wearable biometric devices *prior to the study beginning, with bed and wake times with the Daysimeter*	Figueiro et al., 2011
	Asking time spent outdoors *such as The Munich Chronotype Questionnaire (MCTQ), the Harvard Light Exposure Assessment questionnaire or self-prepared questions to get data about light exposure*	Adamsson et al., 2018
Logs	**Weekly log** *ratings of psychological well-being, daily sleep-activity and time spent outdoors*	Adamsson et al., 2018
	Daily sleep log *prior to the study beginning.*	Jaeggi and Jaeggi, 2011; Yasukouchi et al., 2019
Seat preference	**Surveys and observations** asking for the reasons for the choice of seat locations and direct observations of actual seating behaviour	Organ and Jantti, 1997; Kim and Wineman, 2005; Wang and Boubekri, 2010; Othman et al., 2012; Keskin et al., 2017; Gou et al., 2018
Drawings	**Drawing daylight boundary line** *between daylit and non-daylit area*	Reinhart and Weissman, 2012; Handina et al., 2017
HDR-High dynamic image techniques		Jin et al., 2017; Jung and Inanici, 2019; Chinazzo et al., 2020
Daylight 3D renderings	**Showing the renderings** *with the computer software of the same space to the subjects and ask to rate daylight composition*	Rockcastle and Andersen, 2015
Immersive virtual reality (VR)	**VR with headsets** *such as Oculus Rift CV1 and Oculus Rift DK2*	Chamilothori et al., 2016, 2018, 2019; Chamilothori, 2019

Physiological Biomarkers as a Consequence of Exposure to Daylight

Physiological measurements (biomarkers) are regarded as indicators of previous light exposure; in other words, how much a participant was exposed to light during a specific time. The duration, timing and intensity of exposed daylight may affect people's satisfaction with current daylight conditions and the regulation of their circadian rhythms. Thus, the assessment of physiological biomarkers could play a crucial role in assessing and interpreting an individual's daylight perception.

The objective measurement of daylight perception considers the assessment of physiological biomarkers such as heart rate (Chamilothori et al., 2019; Chinazzo et al., 2020), skin conductance (Chamilothori, 2019; Chamilothori et al., 2019), core body temperature (Chung, 2009; Chinazzo et al., 2020), cortisol level (Jaeggi and Jaeggi, 2011; Choi et al., 2019), and melatonin secretion (Figueiro et al., 2011; Jaeggi and Jaeggi, 2011).

TABLE 3 | The methods for objective measurements.

Method	References
Heart rate (HR) using some devices such as Empatica E4 wristband	Chamilothori et al., 2018; Chamilothori et al., 2019; Yasukouchi et al., 2019; Chinazzo et al., 2020
Skin conductance (SC) using some devices such as Empatica E4 wristband and Electrodermal activity (EDA) wristband	Chamilothori et al., 2018, 2019; Chinazzo et al., 2020
Core body temperature using some devices such as iButtons data loggers and wristband	Chung, 2009; Chinazzo et al., 2020
Cortisol level from salivary	Jaeggi and Jaeggi, 2011; Choi et al., 2019
Melatonin secretion from salivary, blood, urine	Figueiro et al., 2011; Jaeggi and Jaeggi, 2011; Tähkämö et al., 2015; Karami et al., 2016; Choi et al., 2019; Yasukouchi et al., 2019

Heart rate, skin conductance, and body temperature have been measured using wristbands, while melatonin secretion is measured using either salivary, blood, or urine samples.

Subjective Assessment of Daylight

Since individuals are physically and psychologically influenced by daylight (Chung, 2009), objective measurements should be complemented with subjective evaluations. However, some studies (Galasiu and Veitch, 2006; Bellia et al., 2017; Lo Verso et al., 2021) have shown that correspondence between exposed daylight conditions and subjective assessment of the occupants is not always observed because of individual differences. Subjective assessment methods mainly use questionnaires to obtain information through semantic differential techniques, measuring the participant's overall reaction to specific factors such as ambient illumination of different light sources or horizontal illuminance and brightness of a space (Jin et al., 2017; Albertazzi et al., 2018). Similarly, open-ended questions are used to gain deeper and new insights into the feelings towards daylight conditions, for instance, asking how participants describe the lighting conditions and how they feel under those conditions. Information is usually collected concerning the participants' background (age, gender, work schedule, sleep and wake times, previous daylight exposure etc.), their evaluation of daylight illuminance and distribution, and their general satisfaction with the indoor environment (Levin, 2017).

As a method for assessing previous daylight exposure, questionnaires require participants to estimate the frequency of exposure to daylight in a particular period (Adamsson et al., 2018). For instance, the Munich ChronoType Questionnaire (MCTQ) involves estimating the time spent outdoors on workdays and free days, assuming regular light exposure patterns. Likewise, the Harvard Light Exposure Assessment questionnaire (H-LEA) emphasises the importance of time duration and period of light exposure during the daytime to various artificial and natural light sources. Information about previous daylight exposure is also collected with the use of devices that participants are asked to wear, for example wristbands, Daysimeter and ACM (Chamilothori et al., 2019) before (Figueiro et al., 2011) and/or during the experiment (Rea et al., 2010). The collected data is often supported by self-written logs (Adamsson et al., 2018). These devices are also used to gain insight into the activity and sleep pattern of the participants and the amount of daylight they were exposed to.

Few researchers have preferred other subjective methods such as interviews to test the influence of different daylighting configurations on participants' daylight perception (Dianat et al., 2013; Gentile et al., 2015). Moreover, the use of evaluation techniques, such as seat selection, have been applied, where it has been assumed that daylight perception and expectation are associated with seat preference and window location (Wang and Boubekri, 2010; Keskin et al., 2017). In this case, the selected desk's illuminance level could be used as an indicator of daylight perception. Additionally, a unique method was proposed by Reinhart and Weissman (2012) and also used by Handina et al. (2017), given its potential as a representation tool of how daylight composition can be perceived in a space. Handina et al. (2017) have considered the daylight boundary line method to assess perception through the definition of daylit and non-daylit areas drawn by participants. In this methodology, participants have been required to draw a line whenever they notice a boundary between brightness and darkness in the experiment room. Their initial results showed that the percentage of the area enclosed with the contour line of DA300 lx, 50% (illuminance level of at least 300 lux over at least 50% of the space) in the observed space (55%) is close to the partially daylit area (56%), which is the area perceived as bright by at least 25% of participants. Furthermore, high Dynamic image techniques (Jung and Inanici, 2019) and 3D daylight renderings (Rockcastle and Andersen, 2015) have also been used to evaluate the human perception of the daylight composition found in shown scenes. In the further development of these techniques, subjective daylight perception under various computer-generated conditions has been assessed using scenes displayed with the Immersive virtual reality (VR) technique (Chamilothori et al., 2016).

METHODOLOGY

Fifty MSc students were brought all together to the Bartlett Library, asked to complete a questionnaire before the experiment and undertake a set of tasks while going around the library. The library was assessed during one of the sunniest days in December 2019 (between 13:00 and 14:00); a day with a clear sky was selected to get maximum daylight throughout the library during the experiment. The day and time of the study were decided based on both the previous years' daylighting

data obtained from Public Health England and weather data from the Met Office. All tasks took between 20 and 25 min to complete. Collected subjective responses from participants were evaluated depending on the daylight availability of the room obtained from a lighting simulation tool.

As previously highlighted, the effect of lighting conditions on human perception and expectations should be investigated using objective measurements and subjective evaluations. However, only subjective evaluation methods with different applications could be utilised to complement each other for situations where a considerable amount of data collection from objective measurements may not be feasible and accessible. Thus, in this study, only these subjective evaluation methods were applied; seat preference, subjective ratings and daylight boundary line drawings.

Participants

An invitation to participate in the study was sent *via* email to 348 postgraduate students enrolled in MSc programs at the Bartlett School of Architecture, UCL. Seventy-six responded that they would be happy to be involved in the experiment, but only 50 students (15 males/35 females) aged 20–34 years old were recruited for this study.

In terms of cultural background, the ethnicity of participants and the time spent in London were considered. Eleven participants (22%) described themselves as White, whereas 33 students (66%) stated they have an Asian background. Only five participants (10%) defined their ethnicity as other ethnic backgrounds. Most of the students (72%) were overseas students who had spent less than 3 months in London.

Field Site

The study was carried out in the UCL Bartlett library located on the ground floor of a six-storey building. The library comprises three main study areas (**Figure 1**). The group study area (Room 1) accommodates eight shared desks and four individual cubicles and has two side windows in the north-facing external wall; the library collection area (Room 2) has 12 shared desks and 11 individual desks and several side windows facing north and east orientations; the quiet study room (Room 3) is an open-plan space with a skylight, and 32 shared desks. Details of the rooms and technical properties of the surfaces are illustrated in **Appendix 1**.

Quantification of Daylight Availability in the Library

Parametric modelling and daylight simulations were used to get information concerning daylight availability at desks in each room at the library. Spot illuminance measurements were also used to calibrate the created model. AutoCAD and Rhino were used to produce 2D and 3D drawings of the library. Then, Grasshopper was used to create parametric modelling for lighting performance analysis with Ladybug and Honeybee plugins.

Previous studies show that computer predictions with simulation methods demonstrate higher accuracy than measurements taken in real-world conditions. The simulation method results involve an acceptable amount of error arising from either unpredictable sky conditions at that moment or the incorrect input parameters in the simulation model. Therefore, it is always more reliable to compare daylight performance predictions obtained from computer simulations with physical measurements taken in the real space. Since it demonstrates how much simulation results correspond to actual daylight conditions. Daylight modelling built-in Radiance was validated against actual illuminance measurements at a specific point, date and time. A strong association between simulation results and actual daylight measurements was found ($p < 0.05$, $R^2 = 0.89$). In other words, the difference in values between spot measurements and simulation results are negligible, and simulation results represent the real daylight illuminances with an acceptable error range.

Contribution of Electric Light to Total Illuminance

On the day in which the study was performed, students were exposed to electric light in addition to daylight.

The contribution of electric light to total illuminance was investigated by measuring the electric light illuminances in the middle of each desk using a Konica Minolta Illuminance meter T-10A on the 30 November 2019 between 16:45 and 17:15 after sunset. Thereafter, these illuminances were compared with total illuminance measurements taken during the experiment. The electric light illuminance values on the work planes were found highly correlated with the total illuminance measurements ($p = 0.001$). For this reason, it was assumed that all desks receive the same amount of electric lighting, and therefore variations between them would be due to daylight alone.

Subjective Daylight Assessment Methods

Questionnaire Design

A questionnaire was designed to include the three methods used in this study: seat preference, subjective rating, and daylight boundary line drawings. The questionnaire contained multiple-choice, Likert scale, and open-ended questions and was divided into five sections; the first two sections of the questionnaire were completed by participants before entering the library and considered information regarding (1) demographic; gender, and age, (2) time spent in London (months). The following three sections considered specific questions and tasks related to the methods explored to measure participants' daylight perception; (3) seating preference and reasons for seat selection, (4) evaluation of daylight availability at the best seat selected, and (5) differentiation between daylit and non-daylit spaces (boundary line drawing). The procedure order was specifically designed to start with open questions regarding seat preference, and after then daylight specific questions to lead on to influence the participants' responses, thus the latter questions would not impact the responses to the former ones. Ethical approval for this study was obtained from the UCL Research Ethics Committee in November 2019.

Task 1: Seat Preference

Seating that meets students' needs and preferences could promote a longer stay in the libraries and keep students motivated,

FIGURE 1 | Plan of the Bartlett Library (The red arrows represent the locations from where the photos on the right side of the figure were taken).

influencing their emotions and learning abilities. Many disciplines have extensively discussed the influential factors on seat preference in a learning environment. It has been shown that the affecting factors arising from the physical environment that govern the decision of seat selection are daylight (Othman and Mazli, 2012; Keskin et al., 2017), ambient temperature, type of furniture, proximity to other occupants (Dubois et al., 2009), quietness, outdoor view, privacy, social interactions such as close to friends, entrance or circulation (Gou et al., 2018), students' degree of territoriality and seat arrangements (Kaya and Burgess, 2007).

Even though the importance of daylight on seat preference varies from study to study depending on the function of the room, time interval, time of the day and year (Keskin, 2019), some researchers have proved that daylight is the most important reason for seat selection (Alicia et al., 2019; Izmir Tunahan et al., 2021a,b) and the most frequently chosen as a reason for seat selection (Keskin, 2019). Hence, in this study, it was assumed that seat preference could be used to understand whether participants valued the daylight component. The daylight availability of the selected desk was then considered to be an indicator of the daylight conditions the participant prefers. For this purpose, participants were asked to indicate the three best and the three worst seat locations from the library's seating plan, and within those categories, the most and least liked. They were also asked to specify the reasons for their selection to examine whether the selected desks (best and worst) coincide with those where daylight levels were high and low, respectively, hence if the daylight component is an influential factor when deciding where to sit.

Task 2: Subjective Ratings

The subjective rating method involves asking participants to describe the daylight conditions on a specific desk surface. This method has been utilised in many lighting studies, and many researchers have found participants' own perceptual statements compatible with actual daylight conditions. However, subjective evaluations may not represent daylight availability completely because of individual differences in some cases.

This method was applied to determine the degree to which subjective statements represent daylight availability in a space and investigate whether people perceive daylight conditions in line with actual measurements. The possible reasons causing the variation between actual measurements and people's perceptions could help identify ways to increase occupant satisfaction in the built environment. For this purpose, participants were asked to describe the amount of daylight at the best seat they have selected using a six-option scale derived from the BUS questionnaire (Leena, 2017; from very low to very high; **Figure 2**). Thus, daylight availability at a specific desk was tested depending on how participants perceived it.

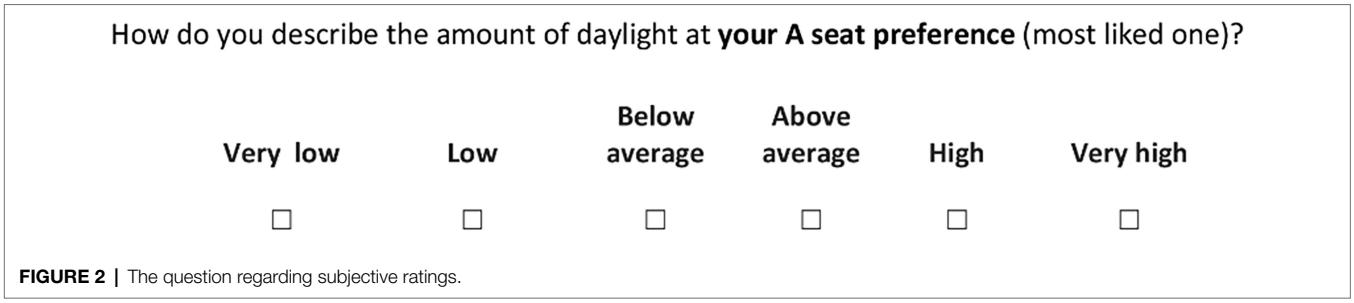

FIGURE 2 | The question regarding subjective ratings.

Task 3: Daylight Boundary Line

This unique method proposed by Handina et al. (2017) was used given its potential to represent how daylight composition can be perceived in a space. For this purpose, participants were instructed to draw on a copy of the library floor plan, 'daylight boundary lines', whenever a significant change of contrast was found or a bright area was perceived when moving around the library (**Figure 3**). The drawn boundary lines were then scanned and overdrawn in AutoCAD to overlay the perceived bright areas, which were assumed to indicate the perception of adequate daylight in this study. Finally, all drawings were superimposed on top of each other and evaluated based on daylight availability at a specific time.

Methods of Analysis

All the statistical analyses were conducted using the software package SPSS 20.0. Univariate descriptive statistics (response frequencies, means, and standard deviations) were calculated for each variable. Evaluations of the data obtained from three subjective methods were carried out separately as described below.

Analysis of Seat Preference

Initially, influential reasons for the best and worst seat selections and the importance of daylight in the selections were considered. Secondly, daylight availability at the best seat selected was evaluated using ordinal regression. Lastly, the best and worst seat selections were evaluated on the seating map concerning other influential factors on seat selections apart from the contribution of daylight.

Analysis of Subjective Ratings

Subjective ratings were evaluated based on the perceived daylight conditions towards daylight availability at the best seat selection using an independent-samples *t*-test.

Analysis of Daylight Boundary Line Drawings

Daylight boundary line drawings were assessed with the methodology created by Handina et al. (2017). Initially, the variation in participants' perceived bright area was analysed using descriptive statistic methods. Secondly, the statistical quartile concept was used to categorise and visualise the areas agreed by a certain number of participants as bright. Spaces were differentiated as *fully daylit* (area agreed as bright by at least 75% of the participants), *partially daylit* (area perceived as bright by at least 25%) and *non-daylit* (area perceived as bright by less than 25% of participants). Lastly, categorised areas representing the participants' overall daylight perception were overlapped with daylight availability to investigate if they correspond with each other.

Analysis of Daylight Simulations

Data obtained from seat preference and subjective rating methods were evaluated based on point-in-time climate-based calculations positioned horizontally in the middle of each working desk, which has been found to have a better association with seating behaviour than other daylight metrics for predicting daylight availability in previous studies (Keskin et al., 2015). Daylight boundary line drawings were assessed using DA300lx,50% (50% of the occupied time when the target illuminance of 300 lux on a horizontal plane is met by daylight) because of a more robust association with the daylight composition of space than others (Handina et al., 2017).

RESULTS AND DISCUSSION

Seat Preference

Reason for Seat Selection

Participants were instructed to select the three best and the three worst seats and indicate the reasons for their selection in an open-ended question. Each participant stated at least one reason for their seat selection (**Table 4**). The number of reasons stated for the seat selection was greater than the number of respondents who answered the question. This caused the total response percentages to exceed 100%.

Daylight was the most dominant reason when selecting the most liked desk, followed by privacy, outdoor view and quietness, respectively. These results align with the findings of Dubois et al. (2009); daylight was the most significant reason for seat selection. Keskin (2019) also reported daylight as a highly mentioned reason for seat selection in their experiment. In other respects, indoor conditions such as temperature and air quality were other influential parameters for seat selection. Other reasons mentioned related to specific desk features were wideness, proximity to the circulation route or entrance, enabling to study individually or with friends, being at the corner or the back of the room and access to facilities such as a computer or plug socket. The worst seats were also associated with unsatisfactory daylight conditions; and with distractive noise, lack of or unpleasant outside view and non-private environment.

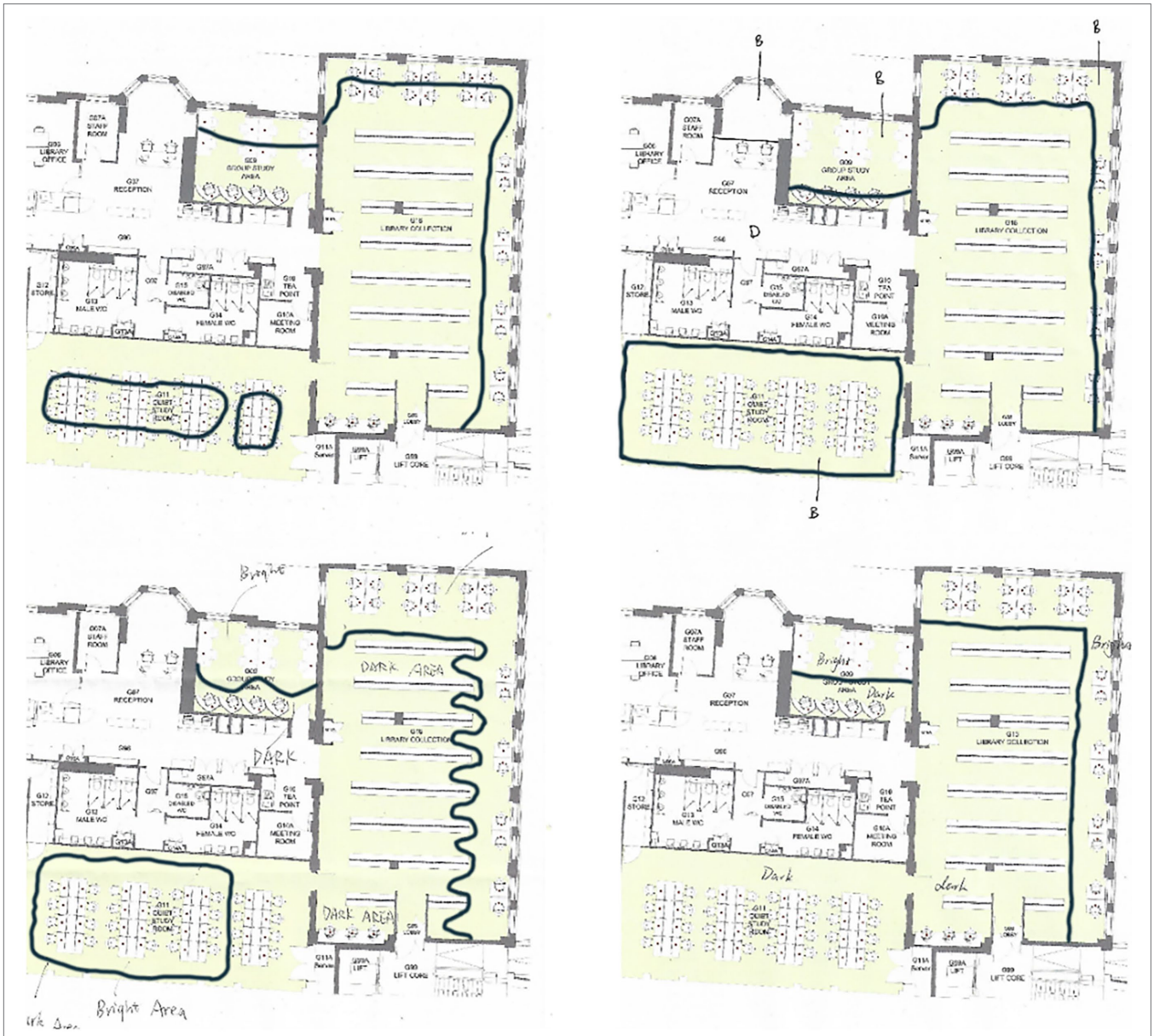

FIGURE 3 | A few examples of participants' drawings in response to the question asking them to draw a boundary line between daylit and non-daylit spaces.

Although, in general, participants seem to agree on the reasons given when selecting the best and worst seats, there were a few cases where a particular desk was selected as the worst and the best by participants. Although seat preference varied from person to person depending on individual needs and expectancies, the majority of the participants considered it important to have a satisfactory daylighting level, face the least people, and have an outdoor view of greenery.

Daylight Availability at the Best Seats Selected

The daylight availability at the best desks selected by participants showed that 44% of the participants ($N = 22$) described the amount of daylight on their best desk as very high, 42% ($N = 21$) stated that the daylight conditions were high, and 6% ($N = 3$) as above average. In contrast, only 8% characterised the daylight conditions as low or very low. These results support the idea that most people prefer desks with a high amount of daylight, which could be with/without consciousness (Kahneman, 2011). Since the awareness of our behavioural responses to the physical environment is limited, and some of our behaviour is not under our conscious control.

An independent-samples *t*-test was also carried out to check whether there was a significant difference in daylight illuminance level of the best seats selected between participants who indicated daylight as the reason for their selection and those who did not. The findings showed that people who mentioned daylight as a reason preferred the desks with much higher daylight illuminance levels (468.5 ± 437.1 lx) than those that did not

TABLE 4 | Participants' responses concerning the reasons for choosing the best (left) and worst (right) seats in the library.

Reason for best seat selections	A best (%)	B second-best (%)	C third-best (%)	Reason for worst seat selections (%)	1 worst (%)	2 second-worst (%)	3 third-worst (%)
Quietness	14.3	4.0	7.7	**Noisy**	19.2	12.5	13.0
Natural light				**Natural light**			
Daylight	53.6	44.0	57.7	Lack of/insufficient daylight	61.5	62.5	52.2
Skylight	10.7	24.0	3.8	Skylight	3.8	4.2	4.3
Proximity to window	14.3	12.0	15.4	No window	0.0	4.2	4.3
Outdoor view	25.0	4.0	15.4	**Lack of/ unpleasant outdoor view**	11.5	12.5	13.0
Privacy				**Privacy**			
Privacy	32.1	20.0	11.5	No privacy	7.7	8.3	0.0
Private position	7.1	8.0	0.0	Non-private position	0.0	0.0	4.3
Feeling isolated	0.0	24.0	11.5	Feeling isolated	7.7	8.3	8.7
Desk				**Desk**			
Desk feature	7.1	4.0	15.4	Desk feature	0.0	4.2	13.0
Desk location	3.6	8.0	15.4	Desk location	23.1	12.5	8.7
Indoor conditions	7.1	4.0	3.8	**Indoor conditions**	15.4	12.5	21.7

mention daylight as a reason (174.9 ± 183 lx), [$t(48) = 2.1$, $p = 0.052$]. It could be explained that daylight availability on a specific desk that meets an occupant's needs and preferences, namely individual daylight expectation, usually influences seat preference. Therefore, daylight availability of the selected desk could be used as an indicator of an individual's daylight preference.

Other Influential Factors

Figure 4 presents the seat preference configuration against the library's daylight availability when the experiment was conducted. The categorisation of lighting levels was done based on the recommended range for library reading rooms (between 300 and 500 lux; Keskin, 2019). It can be seen that most (86%) of the seats selected as the best are located in areas with high illumination, whereas most unpopular desks are located in places with poor or lack of daylight. Interestingly, two desks were regarded as both best and worst by different participants. One of them, located in Room 1, corresponds to an individual cubicle that does not have access to outdoor view or acceptable daylight levels. The desk was selected as the worst seat by a participant because of the deficient daylight level; however, another participant preferred it because the desk was at the corner and more private than others. Another desk, described as both best and worst by five participants, is located near the window and in the corner of Room 2. The desk has a satisfactory level of daylight and outdoor view of greenery, which some participants positively appraised; however, others were negatively affected, given its closeness to an emergency exit and facing the people passing through the circulation route.

Desks in Room 3 under the skylight had a high level of daylight when the study was conducted; however, they were not preferred as expected. The desks near the window in Room 2 were more popular than the desks in other rooms. Six participants stated that they do not feel comfortable in the open-plan layout of Room 3, even though it has excellent daylight levels, especially at some desks. They also mentioned that their screens were visible to other students and that even if it was a silent room, it was easy to get distracted due to facing other people. These findings emphasised that seat preference cannot be examined only in relation to daylight, and it should be investigated together with other components reported in the study such as privacy, outdoor view and quietness.

The role of daylight on seat selection may also vary depending on the context, sample characteristics, and the activities participants are requested to undertake. For instance, this study's results could have been different if the participants were in real need of using the space for their respective studies (e.g., reading and writing for an assignment). In that case, privacy and quietness could have been more important than natural environment components such as temperature, lighting and outdoor view. Therefore, the study design might have affected the participants' natural environmental attention and evaluation of the space and desks. However, although the importance of daylight varies from study to study, it always remains an essential factor for seat selection.

Subjective Ratings

After selecting the best and worst seats, participants were asked to rate the daylight conditions on the work plane at the seat they had selected as the best in the library. Then, the perceived daylight conditions of the participants were evaluated towards daylight availability at the best seat selection using an independent-samples *t*-test. Although some individuals described the amount of daylight different from actual measurements, it was assumed that the contribution of daylight to horizontal illuminance on the desk had a significant effect on the subjective assessment of daylight, $p = 0.002$. The correspondence between subjective ratings

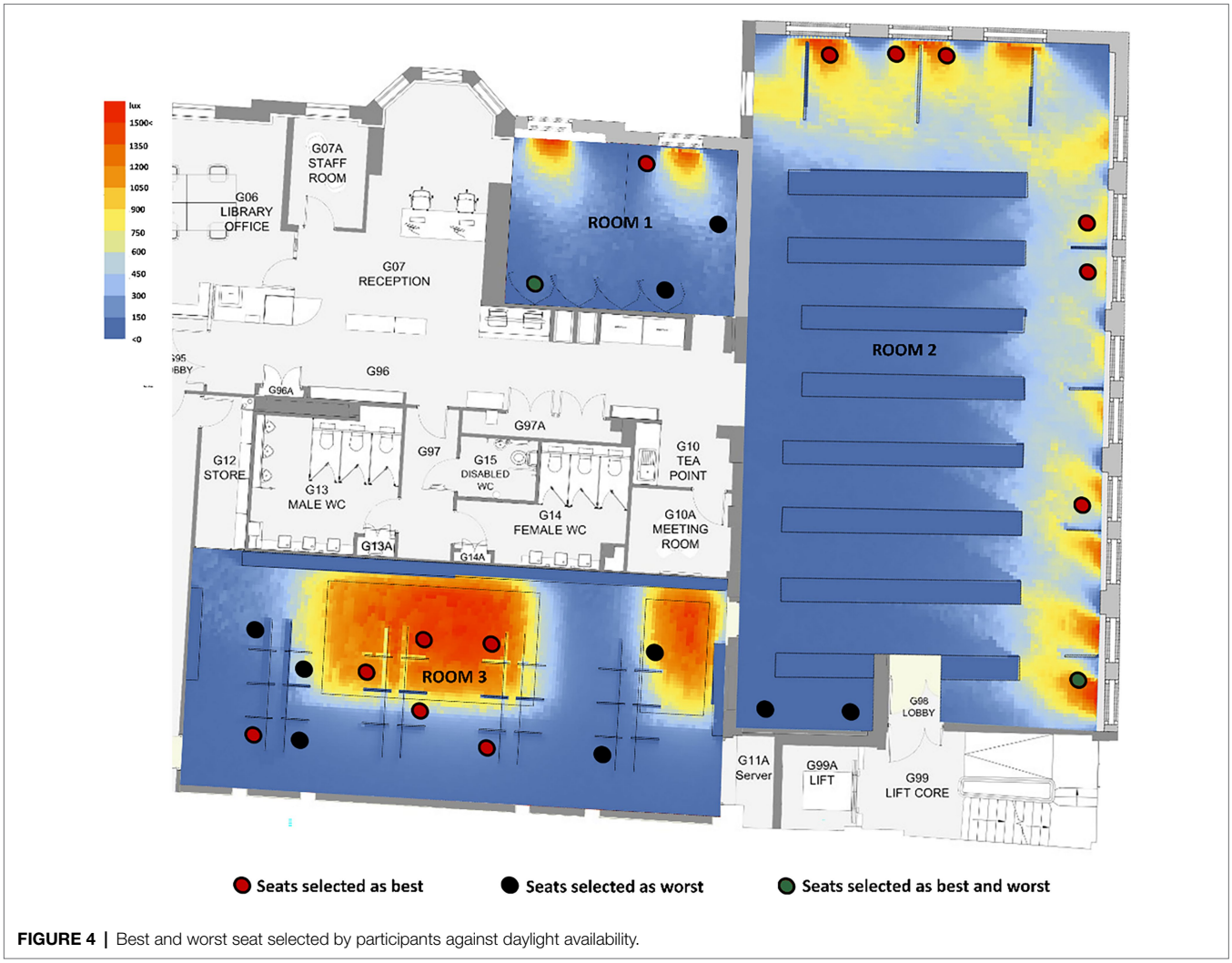

FIGURE 4 | Best and worst seat selected by participants against daylight availability.

and daylight measurements proved that subjective rating is a suitable method for evaluating daylight perception and vice versa. However, even if the difference between the subjective ratings and daylight conditions was minimal, inter-individual differences in perceiving daylight conditions need further investigation.

Daylight Boundary Line

Variation in Perceived Daylight

The library's indoor daylight conditions were assessed by asking participants to draw a boundary line when they noticed a distinction between daylit and non-daylit spaces. A few examples of participants' drawings are shown in **Figure 3**. In this experiment, some participants described the daylight availability in certain areas as very high, whereas others found the daylight in the same areas low or insufficient. The overlapped drawings gathered from all participants are presented in **Figure 5**. Participants' average perceived bright area in the library varied from ~16 to ~100 square meters (mean = 40.3, SD = 24.6, $N = 50$). Perceived daylight conditions varied over an extensive range from person to person regardless of actual daylight measurements. Therefore, aspects that can intervene and cause the discrepancy between actual daylight measurements and participants' perceptions from drawings deserve further attention.

Daylight Availability and the Overall Perception

In order to categorise and visualise the areas agreed by a certain number of participants as bright, the overall perception of daylight composition within each room was evaluated using the statistical quartile concept. Spaces were differentiated as *fully daylit* (perceived as bright by at least 75% of participants), *partially daylit* (perceived as bright by at least 25% of participants), and non-daylit (area perceived as bright by less than 25% of participants; **Figure 6**). Despite the inter-individual differences in the participants' perceived daylight conditions from drawings, there are still apparent areas in the centre of rooms 2 and 3 that all participants agreed to be the dimmest and brightest, respectively.

The participants' overall daylight perception was overlapped with daylight availability in the library to determine the difference between perceived daylight availability from drawings and actual daylight measurements. Handina et al. (Handina et al., 2017) found that the most compatible metric to evaluate boundary line drawings concerning daylight availability in a space is DA300lx,50%.

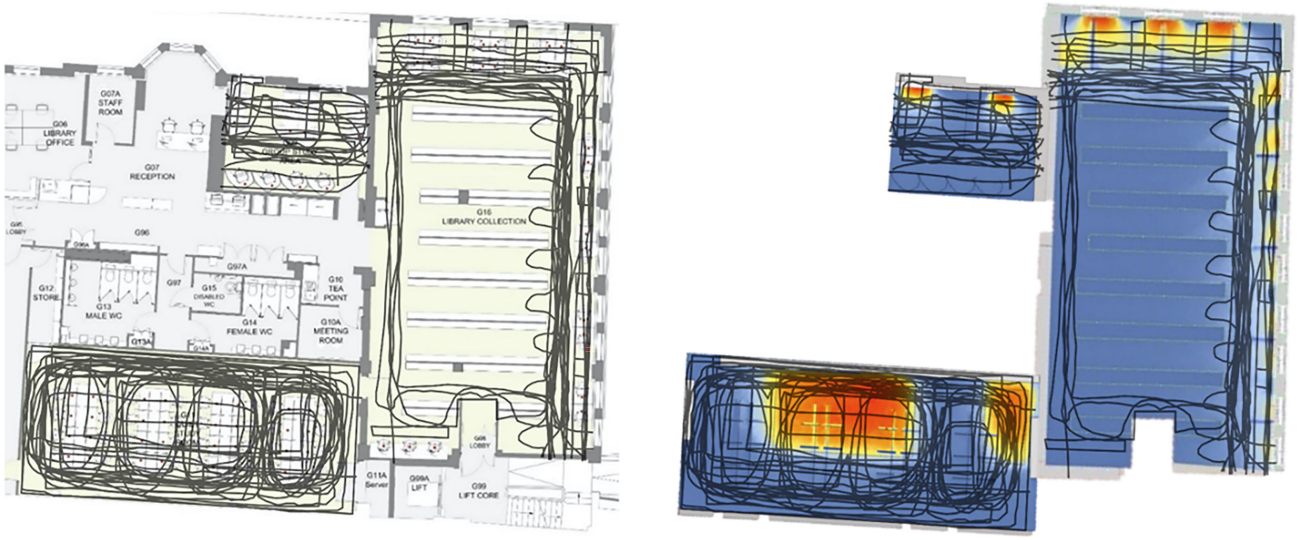

FIGURE 5 | Daylight boundary line drawings of the participants (left), Comparison of drawings with daylight availability (right).

Thus, Daylight Autonomy (300 lx,50%) was used to evaluate daylight boundary line drawings as a daylight availability metric that corresponds to 50% of the occupied time when the target illuminance of 300 lux on a horizontal plane is met by daylight.

As seen in **Figure 6**, only in Room 3, the percentage of the area enclosed with the contour line of DA300lx,50% (41.3%) to some extent, corresponds to the partially daylit area (45.1%). However, the percentage of DA300lx,50%, was not close to the other two rooms' fully daylit areas. Therefore, this method could somewhat explain the tendency in daylight perception of a group of people, despite the noticeable inter-individual differences in the daylight boundary line drawings. It could be useful for comparing daylight perception of a particular group of people, such as people's perceptions living in different latitudes. However, space's characteristics such as the room's size, window type and size, and seat configuration could explain the possible difference in participants perception. Also, as seen in **Figure 5**, the degree of agreement in the participants' perceived bright area varied. Even though perceived bright areas varied from person to person in Room 2 and 3, the agreed daylit space was more noticeable. Perceived bright areas in Room 1 varied on a wide range, and there is no agreement in the participants' perception. These findings agree with Handina et al.'s (Handina et al., 2017) work, where a noticeable difference was found in the subjective daylight evaluations between small and large spaces. Overall, these findings indicate that this method could be used to compare the overall daylight perception of a particular group of people; however, it needs further investigation for the individual assessment of subjective daylight.

Initial Findings From the Developed Methodology

This paper aims to review the methods previously used to assess daylight perception and establish a methodology for assessing daylight perception in the context of cultural background. As mentioned in the results section, seating preference and subjective ratings seem as suitable methods for evaluating daylight perception of individuals. Therefore, as a part of cultural background in the lit environment (Izmir Tunahan et al., 2021), the contribution of ethnic background and time spent in a specific environment to the participants' responses was analysed. The results from the seat preference method showed that when selecting the best seats, the leading reason for 48.5% of Asian participants was daylight, followed by privacy (15.2%), quietness (6.1%) and indoor conditions (6.1%). On the other hand, 33.4% of White participants selected their favourite desks considering daylight as a priority. Subjective rating method results also showed that Asian participants described daylight conditions on the best-selected desks as equal or lower than actual measurements. In contrast, White participants described daylight conditions as similar or higher than actual daylight conditions. This finding shows similarity with Lee and Kim's (Lee and Kim, 2007) study, which showed that Asian people felt more comfortable than Caucasians towards high glare levels of luminance.

In terms of time spent in London, study findings showed that participants that had been in London for longer periods gave less weight to daylight while selecting a seat than students that arrived a couple of months before the study. Four students born and grew up in London preferred desks with significantly less daylight than non-Londoners. In parallel with their seating preferences, students who spent more time in London described the daylight conditions at the best desk as more acceptable. Acclimatisation to daylight conditions over time could affect subjective daylight evaluations and explain this finding just as shown by Martin et al. (Hébert et al., 2002). However, participants' daily routine, how long they are exposed to outdoor daylight conditions and in which timeframe also matter in addition to the daylight availability of the city. Together these findings show that there could be an association between cultural

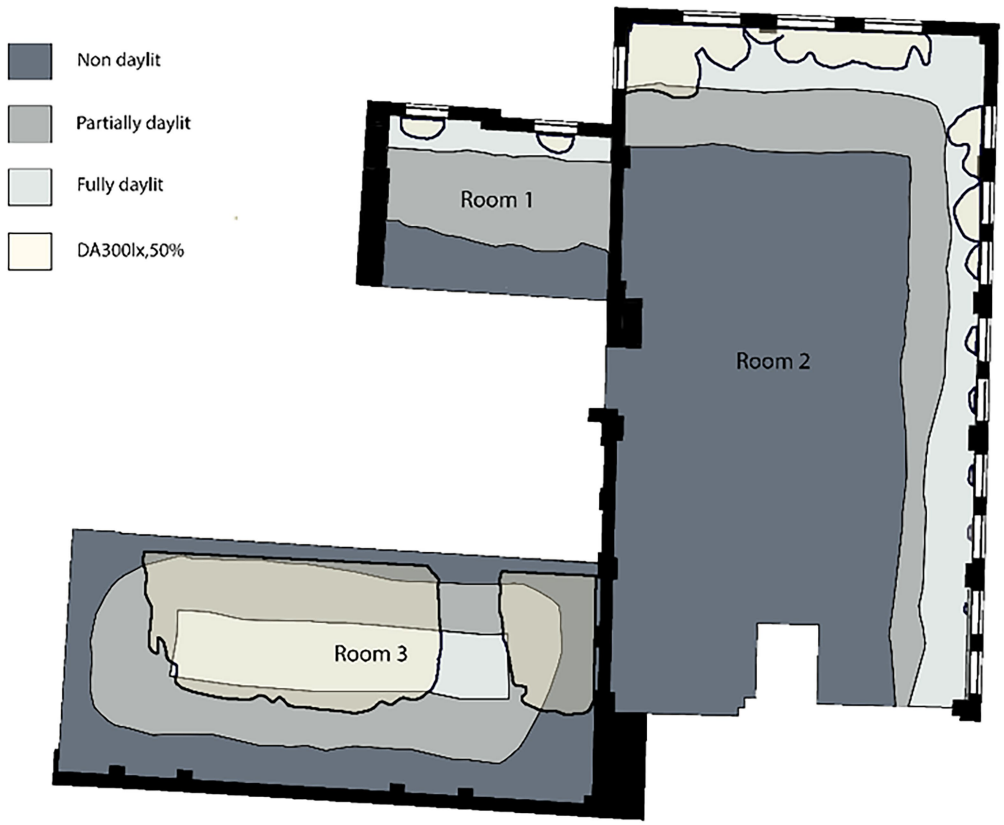

FIGURE 6 | Comparison of the overall daylight perception with percentage of the area enclosed with the contour line of DA300lx,50%.

background and subjective daylight evaluations; however, it needs further investigation with a large sample size of participants considering all cultural background components.

Limitations and Future Work

- The study was limited to a particular place and a particular group of people at a given point in time. The small sample size was another limitation that did not allow to generalise of the findings.
- The role of daylight on seat selection may vary depending on the context, sample characteristics, and the activities participants are requested to undertake. Study results could have been different if the participants were in real need of using the space for their respective studies (e.g., reading and writing for an assignment). In that case, privacy and quietness could have been more important than natural environment components such as temperature, lighting and outdoor view. Therefore, the study design might have affected the participants' natural environmental attention and evaluation of the space and desks.
- Even if the difference between the subjective ratings and daylight conditions was minimal, the reasons for perceiving daylight conditions different from other individuals need further investigation, and inter-individual differences should be examined deeply in further studies.
- The use of drawings to measure participants' perceptions, such as the daylight boundary line method, has some limitations because it involves cognitive and motor processing simultaneously. Therefore, it is suggested (Mitchell et al., 2011) that when a drawing is used as a research method, it should entail participants' drawing and talking, or drawing and writing to interpret the meaning embedded in their drawings.
- The impact of cultural background on daylight perception was evaluated considering only ethnic background and time spent in London. However, cultural background in the lit environment comprises many aspects. Further analysis is needed as suggested by (UKCISA, 2017) considering the luminance environment where people used to live, the luminance environment they were recently exposed to, the socio-cultural background, and individual lifestyle daily routines.

CONCLUSION

Daylighting is an essential component of the indoor environment that can greatly influence the occupants' comfort and wellbeing. For assessing the daylighting quality, photometric measurements on their own do not wholly represent the

subjective aspect of the lighting environment; therefore, more attention should be paid to how participants perceive the same daylight conditions and which method can predict the daylight perception of the participants much better. This paper has presented a summary of current methods for assessing daylight perception and established a methodology for assessing daylight perception in the context of cultural background. In lighting studies, culture represents the many aspects from individuals' characteristics and the climatic and indoor conditions people have experienced. Hence, people from different cultural backgrounds might have different expectations of the lit environment. This knowledge could be used to investigate how users interact with the building and develop strategies to reduce unnecessary electricity consumption in addition to the contribution to human health and wellbeing.

This paper showed that subjective ratings, the amount of daylight described by participants, coincide with the daylight availability on specific surfaces. However, there remains a slight difference between participants' statements and actual daylight conditions. The reasons why daylight conditions are perceived differently by participants need further investigation. The findings from the seat preference method showed that daylight was the most dominant reason when selecting the best desks in the library, followed by privacy, outdoor view and quietness, respectively. Although the reasons for seat selection varied, the majority of the participants agreed on particular reasons; satisfactory daylighting level, facing the least people, and a greenery outdoor view. This study also showed that the perceived daylight conditions obtained from the daylight boundary line method varied extensively from person to person regardless of actual daylight measurements. Therefore, aspects that can intervene and cause the discrepancy between actual daylight measurements and participants' drawings deserve further attention. Initial results from the developed method demonstrated that there could be an association between cultural background and subjective daylight evaluations; however, it needs further investigation with a large sample size of participants considering all cultural background components.

Together these findings showed that subjective rating and seat preference methods could be used to evaluate daylight perception. Although daylight availability corresponds better with subjective statements, collecting participants' subjective responses would not always be possible, especially in large-scale studies. Therefore, the combination of subjective rating and seat preference methods is suggested as appropriate methods for assessing daylight perception. Future research should also consider the impact of other environmental parameters on seat preference and how they relate to lighting conditions to improve occupant satisfaction. The interaction between any parameter and seating choice should not be examined in isolation; other aspects, such as privacy, outdoor view and quietness, should also be considered. Inter-individual differences in daylight perception are also worth investigating further.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, and further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the UCL Research Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

GI conducted the research and reported the results. HA (primary Ph.D. supervisor), JU (secondary Ph.D. supervisor), and CT provided feedback. All authors contributed to the article and approved the submitted version.

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APPENDIX 1

Details of the rooms and technical properties of the surfaces.

		Room 1	Room 2	Room 3
Room geometry (m)	Depth	6.50	19.30	15.20
	Width	4.70	10.30	7.00
	Height	2.81	3.75	2.79
Room reflectance*	Floor (carpet)	0.03	0.03	0.03
	Walls	0.85 and 0.24	0.77	0.85
	Ceiling	0.79	0.79	0.79
	Window frame	0.81	0.81	–
Furniture reflectance	Desk	0.64	0.23	0.67
	Territory element	0.06 and 0.10	0.50	0.13
	Bookshelves	–	0.27	–
Opening geometry (m)	Number of openings	2 windows	13 windows	2 skylights
	Height x Width	1.99 × 1.25	2.58 × 1.25 and 2.58 × 1.68	–
	Width x Depth	–	–	3.20 × 6 and 3.20 × 1.80
Glazing characteristics	Visible transmission	0.60	0.60	0.60
Blinds		No	Yes—Occupancy controlled internal blinds	No
Orientation		N	N—E	–
Outdoor view characteristics		Church	Church and back building facade	Only sky view

**KONICA MINOLTA Illuminance meter T-10A (20014862) and KONICA MINOLTA Luminance gun meter LS 100 were used to measure surface illuminance and surface luminance, assuming perfectly diffusing surfaces, and this formula "Luminance = Reflectance x Illuminance/π" was applied to calculate reflectance of the surfaces.*

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BRIEF RESEARCH REPORT
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Conceptual Integration and Empirical Validation of a Unified Taxonomy: Quantitative Data Analysis for Virtual Learning Environments

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Specific classes of cyberspaces emphasize different types of digital transactions given the user's context, thus making it essential to take into account what these environments can afford. In this way, we can portray the niches of technological use as ecologies of particular possibilities and compare how they differ between distinct spheres of human life. The present research is focused on describing the conceptual integration of a taxonomic crossover between Virtual Learning Environments and Educational Affordances of Technology, while also performing empirical testing and determining the psychometric properties in a scale regarding the aforementioned taxonomy. The study sample consisted of 320 students in the departments of foreign languages from three different universities in Sonora (northwestern region of Mexico). Students were given a questionnaire of 21 items organized into four subscales with a Likert-type response option to measure the notions concerning their usage of Virtual Learning Environments. Internal consistency procedures and confirmatory factor analysis by means of Cronbach's alpha and Structural modeling support the derived factorial structure, which contains Cyber-Communications, Virtual Behavior Settings, Virtual Communities, and Availability and Access to Connectivity. This structure traces the environmental properties perceived by learners in a virtual environment. Results sustain the initial conceptual construction regarding the proposed taxonomy, conclude that the 'Virtual Learning Environments Questionnaire' demonstrates adequate psychometric properties, and validate it as a fitting measure to assess the perceived psychological experience of students in a digital educational setting.

Keywords: educational affordances, taxonomic crossover, psychometrics, empirical validation, virtual learning environments (VLE)

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INTRODUCTION

Categories and classifications are linked to everything humans do, ranging from the worlds where events happen to their complexities and the relationships between them. Categories as material or symbolic tools affect society in several ways: they are assigned, can become labels chosen for different events, and, in turn, can become statistical artifacts (Bowker and Leigh-Star, 2000).

Without a classification, there would be no advanced conceptualization, reasoning, or data analysis. Classifications as taxonomies may refer to both the process and the result. Thus, the term taxonomy is reserved for a theoretical classification of empirical entities. Taxonomical methods, in general, begin with a set of observed data that are measured in a string of variables. Afterward, various techniques, which are traditionally quantitative, are used to group cases on their general resemblance (Bailey, 1994). The present research seeks to develop an exhaustive taxonomy and take it, with an empirical proof, to the operational or indicator level (Bailey, 1984, 1990) by an integration and junction of the concepts that shape each of the selected taxonomies. In this manner, we intend to characterize the main bodies of information and specify the methods that achieve this taxonomic cross.

Numerous concepts and constructs describing virtual learning environments, as well as their corresponding measures, have been proposed in the literature. Research on this topic has evolved to include several instruments designed to evaluate different learning environments by measuring variables such as the efficacy of learners and teachers that engage in them (Chard, 2006); Intrinsic Motivation in virtual learning environments (Fırat et al., 2017); the perceived quality of educational services provided by virtual learning environments (Martínez-Argüelles et al., 2013); scales developed to measure users' engagement in specific virtual environments (Lee et al., 2019; Olivetti et al., 2020; Rojabi, 2020) and The perception of students about pedagogical models and standards in virtual learning environments (Barari et al., 2020; Torres Martín et al., 2021). While these contributions remain to be very significant to the field, they do not provide a general view on virtual learning environments as they focus on the environment's isolated qualities. The taxonomy and corresponding scale presented here differ from prior research because it is sustained by both the educational affordances and spatial qualities of the components of cyberspace, therefore testing the integration of existing taxonomies. This integration will allow to capture the information more completely and to better evaluate virtual learning environments' spatiotemporal qualities and the psychological experience of learners traversing them through their learning process.

The conceptual integration as proposed in this study is focused on describing different components of the cyberspaces or virtual environments, given their potential in learning processes. These components reference the capacity of the Internet and the cyberspace to bring sources of information closer to electronically simulated "virtual" places that are physically distant (Stokols and Montero, 2002). A virtual environment is defined as the experience of being surrounded by an environment synthesized by a computer, mobile device, or cyberspace, which might allow us to state that these types of environments move beyond a three-dimensional context, unlike physical spaces (Stokols, 2018a). In light of their ease of use on mobile devices, virtual environments allow for an interaction with the content and other users without regarding such a device as a computer, but rather as a space and an extension of their habitual daily practices (Lindaman and Nolan, 2015).

Therefore, we agree with the categorization of different components of cyberspace as conceived by Stokols (2018a), where distinct units of cyberspace emphasize different types of digital transactions. This categorization comprises Episodic Cyber Communications, that refer to conversations or exchanges in relatively short or designated time periods that are not as immersive as more extensive online interactions (e.g., E-mail, WhatsApp, Facebook Messenger, Instagram, Skype, and Zoom); Virtual Behavior Settings, meaning sites that stay online during longer periods of time and develop a symbolic sense of "space" or "place." These are frequently built around particular goals or activities (e.g., Blogs or web pages of some particular theme, virtual libraries, different learning management systems such as Moodle and Schoology); and Virtual Communities, the most socially immersive kind of these cyberspaces, which makes reference to groups that involve recurring interactions between participants, who develop a shared identity and a virtual sense of camaraderie. Said cyberspaces often depict members of a community whose interactions and encounters are portrayed on an interface or screen (e.g., Classcraft, learning communities and support groups on Facebook, forums for questions, tutorials, and guides, or sites to make comments and receive feedback on a specific topic).

Other authors have mentioned that, by using taxonomies about virtual environments, we must, in turn, consider what these environments may afford us. Thusly, we may portray the niches of technological use as ecologies of particular possibilities and compare how they differ between specific contexts (Mitev and De Vaujany, 2013). On the topic of what technologies or digital environments afford us in an educational setting, we selected several categories from existing research that explore the *Educational Affordances of wearable technologies* and *Affordances of Information and Communication Technologies*. In this article, we have retrieved mutual components to conceive a category that integrates the affordances of Accessibility, Diversity, Communication, Presence, and Distribution (Boyle and Cook, 2004; Conole and Dyke, 2004; Bower and Sturman, 2015).

Finally, when contemplating cyberspace categories and what they afford us in regard to education, it is pertinent to comment on the material and physical possibility of the availability and access to the connectivity that students have in their places of study. This concept refers to the availability of equipment and services for connectivity in the learning environment, such as Hardware, Software, Internet connection (broadband, wireless, or mobile data), and Educational platforms that are used in everyday learning practices, since the access and usage of these resources in education improves quality, enhances creative thought, is associated to productivity and efficiency of educational results, and facilitates both the teaching and learning process (Siddiquah and Salim, 2017).

The taxonomy comprised by the aforementioned variables may be illustrated in the following manner (see **Figure 1**).

METHODOLOGY

Participants

The study sample consisted of 320 students (Adults ≥18 years, M = 19.4) in the departments of foreign languages from Universidad del Valle de Mexico, Instituto Tecnológico de Hermosillo, and Universidad de Sonora. This sample included 115 male students and 205 female students, all of them located in the city of Hermosillo, Sonora in Northwestern Mexico. All participants were invited and then volunteered to partake in the online study. Participants also completed several other questionnaires related to language learning variables as part of a broader online study regarding language learning environments.

Instrument and Measures

A questionnaire, called the Virtual Learning Environment Questionnaire (VLEQ), was based on the Taxonomy for Virtual Learning Environments, and developed specifically for its use in this study. It contained 21 items with a closed-ended Likert five-point scale response option (ranging from 0 – strongly disagree, to 5 – strongly agree). The VLEQ comprised four main sections: (1) Episodic Cyber Communications, (2) Virtual Behavior Settings, (3) Virtual Communities, and (4) Availability and Access to Connectivity. Regarding the first three scales, each one of them aimed to assess the suitability of the environmental quality perceived from each of these types of digital spaces dedicated to learning. As for the fourth scale, it was designed to gather information about the students' availability of equipment and services for connectivity.

Procedure

The VLEQ Questionnaire development procedure began in November 2020, based on a literature review and structuration of the taxonomic cross in this study. This was carried out with a review of major studies in the area, regarding virtual environments and the affordances of information technologies. Review evolved as ensued by peer feedback, followed by the technique proposed by Bailey (1994), where the planned selection and precise combination of a set of criteria with empirical referents served as a foundation for the taxonomy, and as a result obtaining the 21 Item pool which was to be proved through factor analysis, in order to identify the underlying relationships between measured variables.

The questionnaire was written in Spanish, and it was made available to students from March to April 2021. The recruitment process was tailored to ensure that the learners received the questionnaire via a link shared by their teachers, and then answered during their online classes. The VLEQ link provided also contained the informed consent clause which was signed by all participants.

Data Analysis

The classic strategy is one of the most prevalent practices in social research, which first consists in specifying the concepts or constructs and then measuring empirical cases of them. This strategy alludes to a basic type of indicator classification called a "three-level measurement model," where we find the concept, the corresponding empirical occurrence of the concept, and the indicator of both the concept and the empirical occurrence (Bailey, 1984). In these cases, typologies of a conceptual or empiric nature can only be abstracted through a measurement process which objectively identifies empirical cases for each conceptual category by measuring their correspondence (Bailey, 1994).

The main form of data analysis to be presented here is the results of the analysis from structural modeling procedures used to determine the taxonomy's empirical validity and therefore

TABLE 1 | Internal consistency of the scales.

Scale	Cronbach's alpha (α)
Virtual Learning Environment Questionnaire	
Episodic Cyber Communications	0.94
Virtual Communities	0.91
Virtual Behavior Settings	0.93
Availability and Access to Connectivity	0.91

TABLE 2 | Pearson's correlation coefficients between the scales contained in the Virtual Learning Environments Questionnaire.

	CC	VBS	Vir. C	AAC
CC	1			
VBS	0.789**	1		
Vir. C	0.702**	0.800**	1	
AAC	0.582**	0.648**	0.617**	1

***p < 0.01; n = 320.*
CC, Cyber Communications; VBS, Virtual Behavior Settings; Vir. C, Virtual Communities; AAC, Availability and Access to Connectivity.

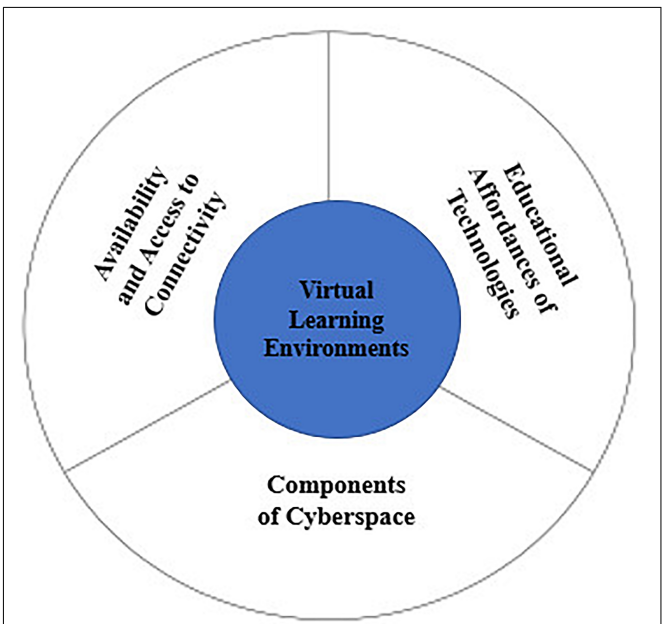

FIGURE 1 | Integrated taxonomy for virtual learning environments.

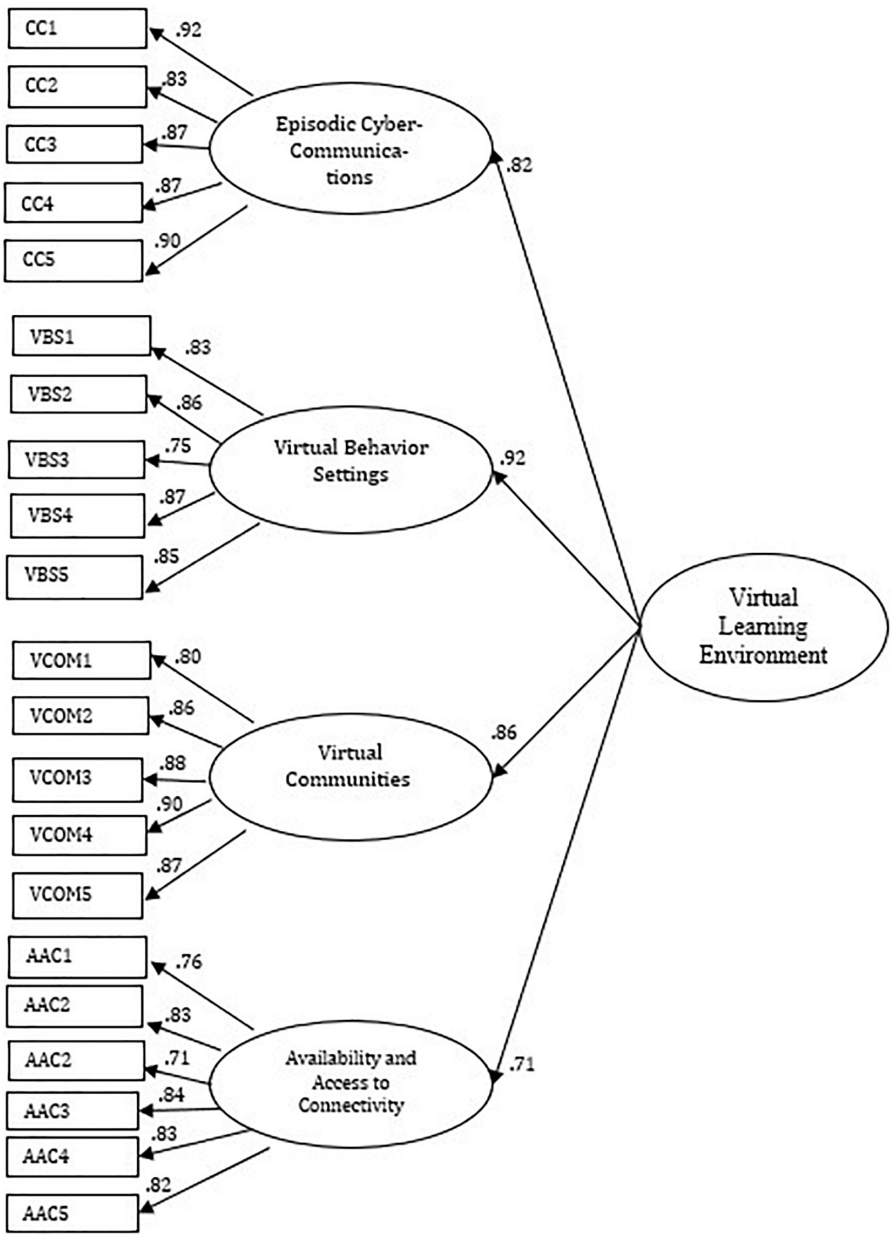

FIGURE 2 | Structural equation model of second-order factor virtual learning environment with four first-order factors. All factor loadings are significant ($p < 0.05$). Values of errors are not reported. Goodness of fit: $\chi^2 = 668.04$ ($df = 179$), $p = 0.000$; BBNFI = 0.92, BBNNFI = 0.93, CFI = 0.94; RMSEA = 0.08. Circles indicate latent variables, and boxes indicate the number of the item.

the VLEQ's reliability and construct validity. Specifically, we aimed to provide the first test of the factorial structure, presented here in two stages. The first step was to execute an Internal consistency analysis by means of Cronbach's alpha reliability coefficient employing SPSS software. This coefficient was chosen in accordance with the needs of the study, given that it refers to the degree that the items of a measurement altogether reflect a simple latent variable (Cohen et al., 2012). Secondly, we demonstrated the validity of the approach by performing a confirmatory factor analysis by the means of structural equation modeling and a covariance analysis between the four factors developed with the proposed taxonomy. The modeling of latent variables provides convergent and discriminative evidence of the validity of the construct (Cohen and Swerdlick, 2006); the latter is assessed by examining the chi-square (χ^2) statistic and its degrees of freedom. Moreover, other indexes used to estimate model fit include the Normed Fit Index (NFI), Non-normed Fit Index (NNFI), Comparative Fit Index (CFI), and Root-Mean-Square

Error Approximation (RMSEA); all of which can be computed in EQS software.

RESULTS

Reliability and Internal Consistency

All scales in this study were individually tested. Since, for the most part, tests are not always assumed to be homogeneous; but rather, it is sought that each of its scales, separately, measures a set of traits or characteristics different from those measured by the other scales included in the test (Cohen and Swerdlick, 2006). **Table 1** shows the internal consistency of the scales used in the study. We can observe that all round, scale coefficients are both statistically significant and strongly correlated (see **Table 2**), presenting high Cronbach's alpha values ($\alpha \geq 0.75$), hence, demonstrating an excellent internal consistency and reliability coefficient of the questionnaire.

Confirmatory Factor Analysis and Model Fit

With regards to model fit and its interpretation, **Figure 2** shows the obtained model for the Virtual Learning Environments Taxonomy, which shows a second-order factor explained by four first-order factors. We employed absolute fit indexes such as chi-square statistic to assess the degree to which the proposed structure and the actual data variance compare (Bentler, 1995). By observing it, we can corroborate that the indicators of goodness of statistical adjustment were in this case significant ($\chi^2 = 668.04$, $df = 179$, $p = 0.000$). However, we may also remark that all factorial loads are equal to or greater than 0.70, and adjunct or practical goodness of fit indexes (NFI = 0.92, NNFI = 0.93, CFI = 0.94, RMSEA = 0.08) show that the model is well supported by the amount of observed data contained in our sample since fit index all values are equal to or greater than 0.90 and RMSEA $\leq$ 0.08 (Bentler, 1990; Corral-Verdugo, 1995; Ullman and Bentler, 2012), thus, proving an adequate factorial structure and model fit regarding its practical indicators, which brought additional information about the value of the hypothesized model (Thompson, 2004; Shi et al., 2019; Park and Kim, 2021).

DISCUSSION

The results from this study point to the conclusion that the conceptual integration and empirical validation of the unified taxonomy for Virtual Learning Environments were solidly constructed and verified. Once indicators are classified into their designated groups, discriminant analysis works with all variables linearly to make a prediction as to the group to which the indicator belongs. This means that a collection of empirical cases assigned to groups and a set of continuously measured variables come to represent the conceptual-indicator-empirical structure obtained via discriminant analysis (Bailey, 1984).

Therefore, by acknowledging this model, this research is a first step toward a more profound understanding of virtual learning environments and study of the scope and complexity of the cybersphere in educational settings. Literature on virtual or digital environments indicates we should consider the cybersphere as a broad domain of environmental influence and search for ways to assess the varied outcomes of virtual life in relation to people's contexts (Stokols, 2019a). Here, we explored some of the contextual relationships embedded in virtual learning environments, approaching the study of how technologies and virtual settings may afford a sense of ecological presence (Frielick, 2004). While touching on the impact of virtual environments in educational settings, we can also make an emphasis on how digital communications and the components of the cybersphere have an influence on a person's day-to-day activities (Stokols, 2019b). In this case, an influence on students' activities and the qualities they perceive from their digital environments. Moreover, the model in this study may shed a light on strategies for digitalized or remote learning and teaching, tactics for adapting to change within the transition to online learning, and the design of digital learning spaces (Abdelhafez, 2021; Lyu, 2021).

A key strength of this research lies within the fact that the newly proposed questionnaire (VLEQ) specializes in studying some of the perceived affordances in virtual learning environments solely based on the items derived from a taxonomic cross which included theoretical categories that had not been tested with empirical cases before. These indicators were subjected to empirical testing procedures in order to obtain and analyze the psychometric properties which determined the validity of the taxonomy portrayed in the questionnaire.

Even in light of the results obtained, a significant limitation in this study relates to generalization, since we worked with data from only 320 second language learning students at university level, therefore the results cannot be claimed to universally be the case for all learners and educational degrees. Furthermore, this work only offers limited aspects regarding each category for virtual learning environments, future directions may point to the improvement of several features of the taxonomy. These may be explored by further development of the questionnaire, such as adding more examples to better describe the different kinds of cyberspaces or including more items in order to describe other affordances of information technologies.

The obtained results justify further development of the method, several interesting aspects may be explored to a greater extent by adapting the instruments and methods of this study to the needs of other populations in different educational levels. Future works should include different kinds of students (including different areas and fields of knowledge), while also associating their virtual, physical, and social contexts in order to further detail the interconnection between these environments and its impact on variables related to learning processes.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Committee of Ethics in Research (Comité de Ética en Investigación) of the University of Sonora. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MM-B contributed to the conceptualization and design of the study, acquired the data, ran formal analysis, and organized the databases. BF-S and GF-B contributed to supervising the study, methodological tasks, and data interpretation. CT-F made substantial contributions by editing and revising the manuscript critically for important intellectual content. MM-B and ON-C provided the writing of the original draft. All authors contributed to manuscript revision and read and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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Effect of Frugality and Cognition on Forest Health Tourism Intention–A Mediating Effect Analysis Based on Multigroup Comparison

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At present, the market demand for forest health tourism is weak. The main purpose of this study is to investigate whether frugality inhibits the intention of forest health tourism and whether the positive effect of cognition on the intention of forest health tourism can compensate for the inhibition of frugality. Based on mental account theory and planned behavior theory, this study constructs a structural equation model with intermediary variables—health consumption mental account and forest health consumption attitude. According to the results of the path analysis of the data, which was collected through the questionnaire survey of urban residents, the positive influence of cognition can compensate for the inhibitory effect of frugality. On this basis, mediating effect analysis based on multigroup comparison is further carried out. This study verifies for the first time the inhibitory effect of frugality on the intention for forest health tourism, enriches the theoretical system of tourism consumer behavior, and provides a scientific basis for the market positioning of forest health and the formulation of marketing strategies.

Keywords: frugality, cognition, mental account, forest health tourism, behavioral intention

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INTRODUCTION

At present, with the increase in the subhealthy population and the acceleration of population aging, the number of chronic diseases in China is growing rapidly (Li et al., 2019). According to existing statistics, the disease burden caused by chronic diseases in China exceeds 70%[1] of the total burden of disease. With the implementation of the Healthy China Strategy and increasing public health awareness, the forest health industry came into being. The forest health and maintenance industry is a kind of tourism service complex that relies on forest resources (forest parks) and integrates the concepts of tourism, leisure, health preservation, sports, medical treatment, and poverty alleviation into the development of forest ecological services. It has become a new form of integrated development of ecological forestry, tourism, and health services. Forest health tourism comprise various vacation tourism activities that are beneficial to human physical and mental health based on high-quality forest resources (Deng, 2016). Studies have shown that the large number

[1]http://www.gov.cn/zhengce/content/2019-07/15/content_5409492.htm, Opinions of the State Council on Implementing Healthy China Action (National Development (2019)13).

of negative oxygen ions and phytochemicals in forest environments play an important role in the prevention and adjuvant treatment of mental and chronic non-communicable diseases (Lee et al., 2015; Ohe et al., 2017). The development of the forest health tourism industry plays an important role in improving people's well-being, protecting forest resources, and promoting the transformation and upgrading of the forest economy (Cong and Zhang, 2016).

Since 2015, China has vigorously promoted the forest health industry (Cong and Zhang, 2016; Chen, 2021). Although thousands of units have been rated national forest health base pilot construction units, only 96 units have been officially awarded the national forest health base title. Due to the sluggish market demand for forest health tourism, these units have made little investment in forest health projects. The main features include forest trails and forest yoga, with Taiji and other activities held occasionally. Most studies on forest health are limited to the concept of forest health, problem analysis, and countermeasures (Sun et al., 2021). Previous studies on forest health tourism intention using the theory of planned behavior (including the extended theory of planned behavior) (Xie et al., 2019) did not provide specific information on the effect of tourism destinations and prices on consumer attitudes, which made it difficult to measure real consumer attitudes and specific behavioral intentions. At present, there is few literature exploring the effect of frugality and cognitive levels on forest health tourism intention. In previous studies on sociology and management, the research on frugality has not attracted enough attention from scholars (Mark, 2016). There are relatively few research results on frugality, and frugality, as an important factor affecting consumers' willingness for forest health tourism, has been ignored by scholars. In addition, there has not been a clear definition and academic definition of forest health tourism cognition.

As the core concepts in the field of psychological research, the research on mental account and theory of planned behavior has been very mature, but they have never been used as mediator variables in the research on forest health tourism intention. Mental account theory tells that people's decision-making depends on mental accounts rather than real accounts, that is, people unconsciously allocate wealth to different accounts for management, and different mental accounts have different accounting methods and psychological operation rules. The way and rules of mental accounting are different from those of economics and mathematics, and often affect individual decisions in unexpected ways (Liu P. et al., 2019). In the field of human behavior prediction, the theory of planned behavior is one of the most commonly used explanatory models (Ajzen, 2011). This theory points out that the intention of attitudes, subject norms, and perceptual behavioral control together shapes individual behavioral intentions and behaviors. The combination of mental account theory and theory of planned behavior will establish a possible interpretation framework for forest health tourism intention.

To sum up, the current research on forest health tourism at home and abroad is mostly limited to the development status and concept connotation of forest health tourism, and the research and discussions are not in-depth, and there are few studies on the influencing factors of forest health tourism intention. At present, forest health tourism has attracted much attention, but the forest health tourism market is weak. Therefore, focusing on understanding the factors that hinder consumers' forest health tourism willingness, to explore the strategy of driving consumers' forest health tourism willingness will be the focus of future forest health tourism research. This study explores the role of frugality and cognition in forest health tourism, which not only fills the gap of research on factors influencing forest health tourism intention, but also provides corresponding countermeasures and suggestions for the development of forest health tourism destination. At the same time, health account and consumer attitude are taken as mediating variables in this study, which is another application of psychological concepts in the field of consumer behavior.

Based on mental account theory and planned behavior theory, this study constructs an analytical framework to reveal the comprehensive influence of mental account, attitude, and subjective norms on forest health tourism intention from the perspective of frugality and cognition and uses a multigroup analysis method to explore the differences between groups, aiming to provide a decision-making reference for forest health tourism enterprises to accurately determine product market and formulate marketing strategies to promote the economic development of forest areas.

THEORETICAL REVIEW

Frugality Habits

As a core concept of traditional consumption in China, frugality has gradually been incorporated into consumption ethics (Tan et al., 2015). Frugality is the conscious reduction of consumption according to one's intentions and defines an anti-consumption lifestyle (Albinsson et al., 2010; Nepomuceno and Laroche, 2015; Kropfeld et al., 2018; Khamis, 2019). Frugal consumers are careful in their daily product purchases and consumption habits (Rose et al., 2010), resulting in a negative effect of frugality on consumption expenditure (Pan et al., 2019), which means they reduce their consumption intentions (Philp and Nepomuceno, 2019). Frugality is generally considered to involve the planned use of resources and avoidance of wasteful behavior (Young, 1986), which does not fail to meet people's basic life needs but does require people to restrain their desires (Gao, 2010). Consumer ethics holds that frugality and luxury are two opposite moral evaluation criteria (Xing, 2018) and regards frugality as morally positive (Muradian, 2019).

At present, frugality is divided into two types from the perspective of behavioral motivation. The first is extremely purposeful frugality, which involves achieving a more important long-term goal by limiting short-term consumption impulses and allocating only resources (Lastovicka et al., 1999). For example, people use the money saved in daily life to purchase luxury goods and real estate. The second is simple frugality, which is frugality behavior formed only to save resources and not used to achieve a specific consumption goal (Pepper et al., 2009).

The second type of frugality, the habit of frugality consumption formed to conserve resources (money, hydropower, etc.), is considered in this study.

Mental Account Theory

Under the assumption of complete consumer rationality, traditional consumption expenditure theory cannot perfectly explain the actual thinking modes, and consumption decisions of consumers (Ge et al., 2019). Individual consumption decisions are affected by mental accounts (Liu P. et al., 2019). Mental accounting is the mental cognitive process by which individuals or families classify, store, encode and estimate the income sources and payment directions of wealth mentally when making a consumption decision (Kivetz, 1999; Li and Ling, 2007) and involves evaluating a variety of choices individually (Kahneman and Tversky, 1984). Since Thaler (1999) formally proposed mental account theory, "Mental Account" has been summarized as a cognitive operational stereotype used by individuals and families to record, organize, and evaluate consumer activities (Benartzi and Thaler, 1999).

In recent years, domestic scholars have systematically conducted research on mental accounts and consumption abroad (Liu Y. et al., 2019) and explored the mechanism of tourism consumption decision-making based on mental accounts (Wang, 2019). The health account in this study is primarily the mental account established by urban residents for health consumption expenditures (fitness, health products, health holidays, etc.).

Theory of Planned Behavior

The theory of planned behavior was developed after introducing the concept of "perceived behavioral control" on the basis of the theory of reasoned action (Ajzen, 1991), which provides a systematic analytical framework for explaining and predicting individual behavior research (Yan et al., 2019). According to the theory of reasoned action, most of people's behaviors are under their own control and rational, determined by volitional factors, i.e., behavioral attitudes and subjective norms, without considering the situation that behaviors are not under individual control (Han, 2015). In order to enhance the explanatory power of theory of reasoned action, Ajzen (1991) introduced the variable of perceived behavior control as the third variable influencing behavior along with behavioral attitude and subjective norms, and pointed out that individual behavior could be directly determined by the perceived behavior control and behavior willing variables, thus formed the theory of planned behavior (Qiu, 2017). According to the theory of planned behavior, planned behavioral intention is affected primarily by three factors: behavioral attitude, subjective norms, and perceived behavioral control (Yang and Zhu, 2018). Behavioral attitude is an individual's preference or attraction evaluation of a particular behavior (Juschten et al., 2019). Subjective norms are the social pressure individuals experience when deciding whether to engage in a particular action (Lin and Li, 2016). Perceived behavioral control is the degree of ease or difficulty individuals feel when performing a particular behavior (Goh et al., 2017). Through empirical research, many scholars have proven that this theory has strong universality and practical significance for predicting various planned behaviors of human beings in actual environments (Xu et al., 2016).

As the theory of planned behavior applies to the prediction of a specific behavior, this study provides specific information on forest health destinations (130–160 km from the place of residence), forest environment pictures, time (at least one night), accommodation prices, and forest health curriculum costs that affect participation intention in the questionnaire. There are three types of accommodations available: camping with tents (no accommodation), cabins with outdoor bathrooms ($84 per night, with breakfast), and star hotel rooms ($200 per night, with breakfast). Accommodations include a nutritious lunch and supper. The total cost per capita is between 60 and 90 yuan. Forest rehabilitation courses include three types: free self-help, 20–60-yuan large-scale professional courses and 60–100-yuan professional small-scale courses. Most urban residents have both the time and money to participate in forest health tourism, which means that the influence of perceived behavioral control on urban residents can be ignored. Therefore, this study measures the influence of only urban residents' behavioral attitudes and subjective norms on their forest health tourism intentions.

The "cognition-attitude-behavior" model can further explain the influence mechanism of cognition on attitude and expand the original theory of planned behavior. Cognitive psychology holds that people's objective behavior is the external manifestation of their internal information cognitive processes and is the basis for whether an individual takes a specific action. Consumers' preferences and behavioral intentions are directly or indirectly affected by their cognitions (Cooke and Sheeran, 2004). Under the influence of cognitive rationality, Western mainstream philosophy emphasizes the decisive role of rational cognition on attitudes (Liu, 2017), and behavioral attitudes directly affect individual behavioral intentions (Ajzen, 1991). Therefore, when explaining the role of cognition, the "cognition-attitude-behavior" theoretical model is gradually established; that is, when an individual perceives something, it produces a corresponding cognition, which affects the individual's attitude toward the thing through cognition and then affects the individual's behavioral intention (Deng et al., 2018). On the whole, the more information individuals have, the higher their degree of identity, and the more vulnerable they are to their attitudes toward the matter, thus affecting their behavioral intentions.

RESEARCH HYPOTHESIS

Frugality, Health Account, and Behavioral Attitude

Since the Chinese population regards frugality as a traditional virtue, it informs the culture's unique values in life consumption (Wu et al., 2012), which is obvious in the consumer mental account. Consumers divide their wealth into several separate accounts in daily life, and their mental accounts vary with commodities (Li et al., 2014). Consumers' frugality habits will affect the size of health accounts, and even determines the existence of health accounts. Especially when forest health tourism exists as a kind of hedonic consumption, tourists with

strong frugality habit will even consider closing the health account. In the process of exploring the influence of frugality on health accounts, this manuscript holds that the more frugal urban residents are, the smaller their health accounts may be, according to the mental account theory. Accordingly, the following assumption is made:

H1: Frugality has a negative effect on health accounts.

In previous frugality studies, frugality has always been regarded as a good social morality, emphasizing rational planning and enjoyment of life (Deng and Cheng, 2002), and has had many effects on individual psychology and attitudes. Frugality is aimed at individual desires and does not limit people's normal life needs (Zhao and Gao, 2018). However, individual consumption attitudes are still more or less influenced by frugality. As a restraint of self-consumption, frugality has an effect on the consumer attitude of tourists to participate in forest health tourism from the level of consciousness (Li and Huang, 2014). In addition to the necessary life consumption expenditure, consumers' consumption expenditure attitude will be constrained by frugality when facing hedonic consumption. Under normal circumstances, consumers affected by frugality consciousness will reduce their spending on hedonic consumption. Forest health tourism belongs to hedonic consumption, and tourists with strong frugality habit will be bound by certain constraints, thus affecting consumer attitudes toward forest health tourism. In the process of exploring the effect of frugality on the consumer attitude of tourists participating in forest health tourism, this manuscript holds that the higher the degree of frugality of tourists, the worse the attitude of tourists participating in forest health tourism. Accordingly, the following assumption is made:

H2: Frugality has a negative effect on forest health tourism attitudes.

Cognition and Health Account, Behavioral Attitude

According to mental account theory, consumers' consumption decisions depend on whether they have mental accounts for the corresponding commodities (Thaler, 2008). As mentioned above, frugal consumption habits of tourists affect the establishment of health accounts, but on the other hand, high-cognitive tourists can perceive greater psychological effects when they participate in forest health tourism consumption. The greater the psychological utility perceived by tourists, the more likely they are to set up a health account, thus improving their behavioral intention of forest health tourism consumption (Zeng et al., 2016). To sum up, this manuscript holds that urban residents with a higher awareness of the role of forest health will think that a vacation in a forest environment is a worthwhile consumption choice and are more likely to set up health accounts, resulting in different forest health tourism consumption intentions. Accordingly, the following assumption is made:

H3: Cognition has a positive effect on health accounts.

When consumers face consumption decisions, they start the process of income and expenditure assessment. Meanwhile, cognitive differences lead to differences in mental utility perception and then produce different consumer behaviors (Zeng et al., 2016). When evaluating the consumption expenditure and health benefits of forest health tourism, compared with urban residents with a low awareness of forest health effects, urban residents with a high awareness will perceive greater mental utility, resulting in positive consumer attitudes. At the same time, according to the "cognition-attitude-intention" theory, cognition will affect the attitude of tourists to participate in forest health tourism in the process of consumption decision-making evaluation (Deng et al., 2018). Therefore, this manuscript argues that the higher urban residents' awareness of forest health is, the better their attitudes toward forest health tourism behavior. Accordingly, the following assumption is made:

H4: Cognition has a positive effect on attitude toward forest health tourism.

Health Accounts, Subjective Norms, Behavioral Attitudes, and Forest Health Tourism Intentions

Forest health tourism intention (health intention in brief) is the action tendency of urban residents to participate in forest health tourism, which is closely related to the occurrence of the corresponding behavior. Although the study found that behavioral intention is the most important explanatory variable of the behavior (Godin and Kok, 1996), tourism decision-making, as a complex process full of uncertainty (Seow et al., 2017), is affected by many factors, including mental accounts. Therefore, mental account theory has been gradually introduced into consumer purchase decision-making research (Tian et al., 2016). Studies have shown that mental accounts affect consumers' consumption intentions and behaviors (Li et al., 2012). The fund levels of mental accounts vary and cannot replaced each other. Forest health tourism consumption belongs to health consumption. Whether urban residents have a health account and the size of the health account directly determine the willingness of urban residents to participate in forest health tourism. Based on the effect of mental accounts on behavior willingness, this study suggests that the greater the number of health accounts owned by urban residents, the stronger their intentions to participate in forest health tourism. Accordingly, the following assumption is made:

H5: Health accounts has a positive effect on forest health tourism intention.

In general, individual behavior is affected by social pressure (Lv, 2019). That is, subjective norms directly affect individual behavioral intention (Ajzen, 1991). The effect of subjective norms on individual behavioral intention has been verified in many social behavior studies (Verma and Chandra, 2018; Wang et al., 2018). If individuals do not comply with a code of conduct and ignore the social pressure from their groups, they will be excluded by their groups (Lv, 2019). Therefore, this study claims that urban residents will ask their relatives and friends for their opinions and suggestions before forest health tourism. The more people

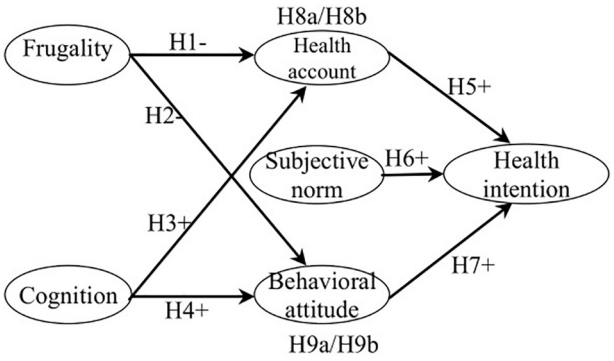

FIGURE 1 | Theoretical model.

around them support and advocate forest health tourism, the stronger their intention to participate. Accordingly, the following assumption is made:

H6: Subjective norms has a positive effect on forest health tourism intention.

Consumer attitude refers to an individual's preference for a certain behavior. Ajzen (1991) predicts through theory of planned behavior that consumer attitude will directly affect an individual's behavioral intention. Individuals' intentions to participate in a behavior increase with their preferences for the behavior. Related studies have shown that individual behavioral attitudes directly affect behavioral intention (Kaushik et al., 2015; Ru et al., 2018). It can be speculated that when tourists have a positive consumer attitude toward forest health tourism, their behavioral intention to participate in forest health tourism will be stronger. This positive consumer attitude will not only affect tourists themselves, but also affect the relatives and friends around them. Therefore, behavioral attitudes reflect individuals' preferences for forest health behavior. Urban residents with positive behavior attitudes are willing to participate in forest health tourism and invite others to join. Accordingly, the following assumption is made:

H7: Behavioral attitude has a positive effect on intention for forest health tourism.

Considering hypotheses H1–H7, hypotheses regarding the mediating effects of health accounts and behavioral attitudes are proposed:

H8a: Health accounts have a significant mediating effect between frugality and forest health tourism intention.
H8b: Health accounts have a significant mediating effect between cognition and forest health tourism intention.
H9a: Behavioral attitude plays a significant mediating role between frugality and forest health tourism intention.
H9b: Behavioral attitude plays a significant mediating role between cognition and forest health tourism intention.

In summary, the theoretical model of this study is shown in **Figure 1**.

RESEARCH DESIGN

Questionnaire Design and Variables Measurement

Although most of the variable measurement items in this study use scales that have been validated in China and abroad, a preliminary investigation of the questionnaire was still carried out to ensure the content validity of the questionnaire, and some items were modified and optimized according to research feedback. After expert review, the final questionnaire was determined (see **Table 1**).

The questionnaire includes the following six parts:

1. Urban resident frugality measurement. This part uses the scale designed by Pepper et al. (2009) and Hampson and McGoldrick (2017), and draws on the three dimensions adopted by Wu et al. (2012), namely, the ratio of goods to goods, the amount of input and output, and the best use of goods. Items measure eating, clothing, and housing. After the reliability test and exploratory factor analysis, three items were finally retained.
2. The cognition measurement of urban residents on the role of forest health tourism is based on studies by Lee et al. (2015), Ohe et al. (2017), and Kleindl et al. (2018).
3. Urban residents' attitudes toward forest health tourism and subjective norm measurement were surveyed using items measuring behavioral attitude adapted from the scale of Xie et al. (2019). On the basis of the original scale items, according to the needs of this study, the corresponding restrictions were added. The measurement items for subjective norms were taken from the scales designed by Deng (2012), Xu et al. (2016), and Ji and Nie (2017).
4. The health accounts of urban residents were measured based on the range of annual per capita spending on health products, fitness, travel, and vacation after the end of COVID-19 using nine options, ranging up to spending more than 5,000 yuan.
5. The items measuring urban residents' forest health tourism intentions (referred to as health intention) were adapted from the scales of Assaker et al. (2011), Prayag et al. (2017), and Xu and Li (2018).
6. The demographic characteristics of the respondents were measured using variables such as gender, age range, education level, income range, and health status.

Considering that the theory of planned behavior is applicable to the prediction of specific behaviors, specific forest health destinations (130–160 km from the place of residence), forest environment pictures, time (at least one night), accommodation prices, forest health curriculum costs, and other related information affecting participation intention were measured by the questionnaire. There are three types of accommodations available: camping with tents (no accommodation), cabins with outdoor bathrooms ($84 per night, with breakfast), and star hotel rooms ($200 per night, with breakfast). The main meal included a nutritious lunch and dinner, and the total cost per

TABLE 1 | Measurement items.

Variable	Measurement items	References
Frugality	I prefer simple and clean economy hotels over more expensive business hotels.	Pepper et al., 2009; Wu et al., 2012; Hampson and McGoldrick, 2017
	When shopping, I always shop around, trying to use the least money, to achieve the maximum purpose.	
	I will save paper boxes, plastic bottles and other recyclable items and then sell them to recyclers.	
Cognition	Plant bacteriocins (Findol) and negative oxygen ions released from forests can promote human metabolism and improve immunity.	Lee et al., 2015; Ohe et al., 2017; Kleindl et al., 2018
	Forest environments can reduce the secretion of adrenaline to some extent and increase the secretion of dopamine in the eyes and improve vision.	
	Forest environments can reduce fatigue, promote relaxation, relieve stress and regulate mental health.	
	Sitting meditation or exercise in the forest can improve memory, hearing and sleep quality.	
	Forest environments play an important role in improving immunity and preventing epidemics.	
Behavioral attitude	I think forest health tourism is a symbol of life interest and quality of life that is worthy of consumption.	Xie et al., 2019
	I think forest health tourism is more effective than exercise in urban parks.	
	I think forest health tourism is worth more than buying health products at the same price.	
	I think forest health tourism is more worthwhile than participating in indoor club fitness at the same price.	
	Compared with not taking part in forest health tourism, I think taking part one time is beneficial for health.	
Subjective norm	My relatives' participation in forest health tourism would affect me.	Deng, 2012; Xu et al., 2016; Ji and Nie, 2017
	My friend's participation in forest health tourism would affect me.	
	Forest health tourism information from social media would affect me.	
Health account	The amount my family spends annually on health products; fitness (including swimming pool, fitness club and gym); and hot spring, forest and seaside vacations is.	Henderson and Peterson, 1992; Kivetz, 1999; Thaler, 1999
	The annual cost of health care products for my family is.	
	The annual spending range of my family for swimming pools, fitness clubs, stadiums and other places is.	
	The annual expenditure range of my family for forest health tourism consumption is.	
Health intention	I would like to advise others to participate in forest health tourism.	Assaker et al., 2011; Prayag et al., 2017; Xu and Li, 2018
	I would like to invite others to participate in forest health tourism.	
	I would like to join a Forest Health Tourism WeChat Communication Group.	

capita is between 60 and 90 yuan. There were three types of forest rehabilitation courses: free self-help, 20–60 yuan professional large-scale courses, and 60–100 yuan professional small-scale courses. Most urban residents have the money and time to participate in forest health tourism; that is, the influence of perceived behavioral control on urban residents can be ignored. Therefore, this study measures only the influence of urban residents' behavioral attitudes and subjective norms on the intention for forest health tourism.

Research Samples

This study conducted a questionnaire survey of residents in Shenyang from April to June in 2020. Because the participants on Credamo and other survey platforms are mostly highly educated, questionnaire distribution through such a platform will lead to poor representativeness of the sample, so this study used the questionnaire star platform to administer the questionnaire and both online distribution via various WeChat groups of owners in different grades of community and offline distribution. In distributing the questionnaires, four steps were taken to control for common method deviance. (1) Questionnaires were distributed in a unified manner so that the questionnaire issuer would not influence the respondents' answers or convey individual emotional tendencies to the respondents, emphasizing that there is no right or wrong answer as long as the answer is logical, to ensure the objectivity of the data. (2) Questionnaires were completed anonymously, and the respondents were ensured that their data would be used only for subject studies to reduce concerns and ensure answers were given truthfully. (3) Invalid questionnaires were quickly screened using the reverse-scored items and specified option items. (4) In the process of questionnaire distribution, there were no clear questionnaire quantity requirements to prevent questionnaire distributors from pursuing quantity at the expensive of quality.

Considering that the research objects are urban residents with tourism decision-making power, a screening question, "When you participate in tourism activities (including a day trip), do you usually following relatives and friends (rather than make your own decision)?" was added to the questionnaire, and if the respondent chose "yes," the answer was deleted. The respondents logged in through WeChat to answer, and each WeChat account and IP address could answer only once to avoid repeated answers. After the questionnaire survey, a total of 465 online questionnaires were submitted, 61 terminated questionnaires were eliminated, and 404 complete questionnaires were received. Then, 183 invalid questionnaires were further

eliminated according to the reverse-scored items, the specified items and the filling times, and 221 valid questionnaires were obtained. The recovery rate of valid online questionnaires was only 54.7%. Fifty questionnaires were distributed offline, and 43 valid questionnaires were obtained. The recovery rate of valid offline questionnaires was 86.0%. A total of 264 valid questionnaires were obtained in this survey. Usually, the effective sample size of the structural equation model should be more than ten times the number of observed variables contained in the model (Bentler and Chou, 1987). When the sample size is not less than 200, the model can obtain stable fitting results (Loehlin, 1992). Therefore, it is believed that the number of effective samples obtained in this study can meet the needs of this study. The sample composition is shown in **Table 2**.

DATA ANALYSIS AND RESULTS

Common Method Deviation Test

Before the data analysis, it was necessary to detect common method bias, which is frequently observed in questionnaire data. In this study, the Harman single-factor test was used to conduct non-rotational factor analysis on the measurement indicators of all variables in the questionnaire. The results show that the variance interpretation rate of the first common factor obtained by the unrotating factor analysis is 22.509%, which is less than half of the total variance interpretation rate, indicating that the common method deviation is within an acceptable range. Considering that the Harman single-factor test is not sensitive enough, this study uses partial correlation analysis for comparison and verification; that is, the first common factor isolated from the Harman single-factor test is controlled and used to measure the partial correlation between variables, and it is found that no common method bias is obvious. Therefore, it can be considered that there is no common method bias in this study.

Exploratory Factor Analysis

To ensure that the actual measurement data match the preset conceptual measurement, this study followed three principles for exploratory factor analysis: (1) Each common factor contains at least three measurement items. (2) The non-response probability of measurement items is less than 10%. (3) The measurement items were excluded if the load value in the rotation factor was less than 0.4 or the factor load value was greater than 0.4 for both common factors. Finally, 23 measurement items were retained (see **Table 1**). Exploratory factor analysis results showed that the KMO value was 0.742, the Bartlett spherical test chi-square value was 2833.996, the df value was 253, and the significance level = 0.000 < 0.05; thus, it is suitable for factor analysis. The characteristic root values of the first six extracted factors were greater than 1, and the total interpretation rate of the cumulative variance in the six factors was 67.027%, which exceeded the extraction limit of 60%, indicating that the extraction of the six factors was reasonable and that the data had good structural validity.

Reliability and Validity Test

The reliability test is a test method for the reliability analysis of variables in questionnaires. In this study, Cronbach's α coefficient was used to test the internal consistency of the scale. All Cronbach's α coefficients are greater than 0.7 (see **Table 3**), indicating that the variable measurement has good internal consistency and is suitable for further analysis. In this study, combined reliability (CR) and mean variance extraction (AVE) were used to test the convergence and discriminant validity of the research model (see **Table 3**).

The data in **Table 3** show that the standardized factor load values of the research model are all greater than 0.7, the AVE values are all greater than 0.5, and the CR values are all greater than 0.8, indicating convergent validity; thus, the research model has good convergent validity.

In the test of discriminant validity (see **Table 4**), the square root of mean variance extraction (AVE) of all variables in this study was significantly greater than the correlation coefficient between variables, indicating that the data used in this study have good discriminant validity.

Path Analysis and Hypothesis Testing

In this study, AMOS 24.0 software was used to analyze the overall goodness of fit of the scale data. Among them, $\chi^2/DF = 1.518$,

TABLE 2 | Descriptive statistics of demographic variables.

Variable	Value	Frequency	Percentage(%)	Variable	Value	Frequency	Percentage(%)
Gender	Male	94	35.6	Annual per capita disposable income	Under 20,000	42	15.9
	Female	170	65.4		20,000–50,000	87	33.0
Age	Under 30 years old	36	13.6		50,000–80,000	69	26.1
	30–44 years	100	37.9		80,000–100,000	26	9.8
	45–54 years	68	25.8		100,000–150,000	22	8.3
	55–64 years	43	16.3		150,000–200,000	10	3.8
	Over 64 years old	17	6.4		Over 200,000	8	3.1
Education	Junior high school	20	7.6	Health status	Very healthy	69	26.1
	High school	23	8.7		Healthy	144	54.5
	Junior college	44	16.7		Sub-health	40	15.2
	Undergraduate	118	44.7		Chronic diseases	10	3.8
	Graduate	59	22.3		Severe illness	1	0.4

TABLE 3 | Results of convergent validity analysis.

Variable	Index	Standardized load	Cronbach's α coefficient	CR	AVE
Frugality	JJ1	0.833	0.792	0.890	0.731
	JJ2	0.764			
	JJ3	0.956			
Cognition	RZ1	0.693	0.811	0.856	0.544
	RZ2	0.706			
	RZ3	0.753			
	RZ4	0.798			
	RZ5	0.734			
Behavioral attitude	TD1	0.711	0.834	0.863	0.557
	TD2	0.741			
	TD3	0.725			
	TD4	0.779			
	TD5	0.774			
Subjective norm	GF1	0.841	0.779	0.861	0.676
	GF2	0.881			
	GF3	0.737			
Health account	ZH1	0.708	0.761	0.840	0.568
	ZH2	0.703			
	ZH3	0.811			
	ZH4	0.787			
Health intention	YX1	0.844	0.901	0.906	0.763
	YX2	0.873			
	YX3	0.903			

GFI = 0.905, RMSEA = 0.044, CFI = 0.957, and RMR = 0.047. The absolute fitting index, relative fitting index, and simplified fitting index of the research model reached the ideal level of model fit, indicating that the research model had good fitness.

The path analysis and test results of this study are shown in **Table 5**.

According to the results in **Table 5**, the standardized path coefficient between frugality and health accounts (JJ → ZH) is −0.152 ($P < 0.01$), indicating that frugality significantly negatively affects health accounts; thus, H1 is verified. The standardized path coefficient between frugality and behavioral attitude (JJ → TD) is −0.001 ($P > 0.05$), indicating that frugality does not significantly affect the attitude of urban residents toward forest health tourism, so H2 is not verified. For urban residents, frugality affects the establishment of their health accounts. However, frugality is aimed at reducing unnecessary costs. When urban residents realize that forest health tourism has a good health care effect, their attitude is not affected by frugality.

The standardized path coefficient between cognition and health accounts (RZ → ZH) was 0.177 ($P < 0.05$), indicating that urban residents' cognition of forest health tourism had a significant positive effect on health accounts, so H3 is verified. The standardized path coefficient between cognition and behavioral attitude (RZ → TD) was 0.496 ($P < 0.001$), indicating that urban residents' cognition of forest health tourism had a significant positive effect on their attitude toward forest health tourism, so H4 is verified. Urban residents' awareness of forest health has a significant effect on their health accounts and forest health tourism attitudes.

The standardized path coefficients of health accounts, subjective norms, behavioral attitudes, and forest health tourism intentions are 0.209 ($P < 0.05$), 0.282 ($P < 0.001$), and 0.281 ($P < 0.001$), respectively, indicating that health accounts, subjective norms, and behavioral attitudes have significantly positive effects on the forest health tourism intentions of urban residents, verifying H5, H6, and H7. The standardized path coefficients between frugality and forest health tourism intention (JJ → YX) and between cognition and forest health tourism intention (RZ → YX) are 0.04 ($P > 0.05$) and 0.095 ($P > 0.05$), respectively, indicating that the effect of frugality and cognition on forest health tourism intention is not significant, and a further mediating effect test is needed.

Test of Mediating Effect

In this study, the bootstrap method was used to test the mediating effect of frugality on the relationship between cognition and forest health tourism intention. The bootstrap method determines the significance of the mediating effect of the model by whether there is 0 between the upper and lower critical values. The specific mediating effect test results are shown in **Table 6**.

The P value and confidence interval in **Table 6** show that the JJ2 path is not significant; that is, behavioral attitude does not have a significant mediating effect on the relationship between frugality and forest health tourism intention, so H9a is not verified. The other three paths are significant; that is, the health account has a significant full mediating effect on the relationship between frugality and forest health tourism intention, verifying H8a. At the same time, health accounts and behavioral attitudes have a significant full mediating effect on the

TABLE 4 | Discriminant validity analysis results.

Variable	Frugality	Cognition	Behavioral attitude	Subjective norm	Health account	Health intention
Frugality	0.855					
Cognition	−0.080	0.738				
Behavioral attitude	−0.125	0.403	0.746			
Subjective norm	−0.036	0.093	0.093	0.822		
Health account	−0.172	0.143	0.133	0.121	0.754	
Health intention	−0.070	0.257	0.352	0.302	0.212	0.873

The value on the diagonal is the square root of the mean variance extraction value (AVE), and the correlation coefficient between variables is below the diagonal.

TABLE 5 | Path coefficient and test results.

Path	Standardization coefficient	Non-standardized coefficient	SE	CR	*P*
JJ → ZH	−0.152**	−0.084	0.029	−2.917	0.004
JJ → TD	−0.001	−0.001	0.028	−0.034	0.973
RZ → ZH	0.177*	0.145	0.064	2.278	0.023
RZ → TD	0.496***	0.486	0.081	5.982	< 0.001
ZH → YX	0.209**	0.252	0.08	3.143	0.002
GF → YX	0.282***	0.293	0.069	4.235	< 0.001
TD → YX	0.281***	0.284	0.078	3.650	< 0.001
JJ → YX	−0.040	−0.027	0.025	−1.089	0.276
RZ → YX	0.095	0.094	0.071	1.312	0.190

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

relationship between cognition and intention to engage in forest health tourism, verifying H8b and H9b. The path coefficients between variables after the hypothesis test are shown in **Figure 2**.

THE MEDIATING EFFECT ANALYSIS BASED ON MULTIGROUP COMPARISON

Mediating Effect Analysis Based on Latent Variable Grouping

The above path analysis shows that frugality and cognition have significant effects on health accounts. Subjective norms and behavioral attitudes have significant effects on forest health tourism intention. Health accounts have a significant full mediating effect on the relationship between frugality and forest health tourism intention. To further test whether cognition, subjective norms and behavioral attitudes have a moderating effect on the path of frugality → health account → forest health intention, AMOS24.0 was used for multigroup analysis of the questionnaire data. Therefore, the variables of cognition, subjective norms, and behavioral attitude were transformed into binary variables. Taking cognition as an example, it is necessary to first generate a variable of cognitive mean value and assign it to the mean value of each cognitive measurement item. Then, the cognitive mean of all samples is calculated. Finally, the cognitive variables above the mean value are assigned a value of 1, indicating the high-cognitive group, and the cognitive variables below the mean value are assigned a value of 0, indicating the low-cognitive group. Similarly, according to subjective norm assignment, the samples are divided into a high norm group and a low norm group, and according to behavioral attitude assignment, the samples are divided into a positive attitude group and a negative attitude group.

Multigroup analysis showed that the CFI, TLI, and IFI values in the model were between 0.9 and 0.96, higher than the standard value of 0.9. The RMSEA values were between 0.05 and 0.06, lower than the critical value of 0.08. This shows that the multigroup analysis model has a good adaptation effect with the sample data. The results of the multigroup path analysis are shown in **Table 7**.

Table 7 shows that in the influence path H1 of frugality on health accounts, the influence on low-cognitive people is significant ($\beta = -0.154$, $P < 0.01$), but the effect on high-cognitive people is not ($\beta = -0.052$, $p > 0.05$), indicating that in the process of setting up health consumption mental accounts, the higher the urban residents' awareness of forest health is, the higher the perceived value of consumption is; thus, the inhibitory effect of frugality on health consumption mental accounts is not significant. In terms of subjective norms, the frugality habits of the low-cognitive group still significantly inhibited the mental account of health consumption ($\beta = -0.148$, $P < 0.01$), while no significant effect of frugality occurred in the high-cognitive group ($\beta = -0.031$, $p > 0.05$), indicating that the inhibitory effect of frugality on the mental account of health consumption is no longer significant with strong herd mentality and group consciousness. The frugality habits of urban residents who hold negative attitudes toward forest health still significantly inhibit mental health consumption accounts ($\beta = -0.108$, $P < 0.01$); however, for the urban residents with a positive attitude toward forest health, their frugal habits had no significant inhibitory effect on the mental account of health consumption ($\beta = -0.058$, $P > 0.05$).

In path H5 of the effect of health accounts on the intention for forest health tourism, there is no significant difference across groups, indicating that the positive effect of health accounts on the intention for urban residents to engage in forest health tourism is stable and is not related to the level of cognition or subjective norms or whether the attitude is positive or negative.

In the influence path H8a of frugality on urban residents' intention to engage in forest health tourism, there was no significant difference between groups, indicating that frugality

TABLE 6 | Standardized bootstrap mediation effect test.

Path	Estimate	SE	Bias-corrected 95%CI			Percentile 95%CI		
			Lower	Upper	*P*	Lower	Upper	*P*
Stdind JJ1	−0.032	0.015	−0.077	−0.011	0.001	−0.065	−0.007	0.003
Stdind JJ2	0.000	0.016	−0.029	0.034	0.934	−0.028	0.036	0.975
Stdind RZ1	0.139	0.046	0.07	0.257	0.001	0.064	0.242	0.001
Stdind RZ2	0.037	0.020	0.007	0.090	0.011	0.002	0.078	0.030

JJ1 indicates: frugality → health account → forest health tourism intention. JJ2 indicates frugality → behavioral attitude → forest health tourism intention. RZ1 indicates cognition → behavioral attitude → forest health tourism intention. RZ2 indicates cognition → health account → forest health tourism intention.

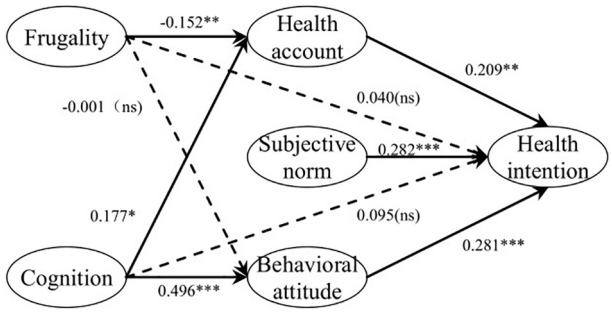

FIGURE 2 | Hypothesis test results. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. ns represents p is not significant. The unbroken line represents significant paths, while the dotted line represents non-significant paths.

affects the intention to engage in forest health tourism only through health accounts.

In summary, for urban residents with low awareness of forest health, low levels of subjective norms and negative attitudes, the complete mediating effect of health accounts on the relationship between frugality and forest health tourism intention always exists. That is, for this group, frugality inhibits the establishment of health accounts, which has a significant negative effect on forest health tourism intention.

Mediating Effect Analysis Based on Demographic Variables Grouping

To explore the differences in path parameters between frugality → health account → forest health intention across groups, four demographic variables, gender, education, age, and income, were selected for multigroup analysis. For education, a bachelor's degree was used as the boundary, with those with less than a bachelor's degree in the low-degree group and those with a bachelor's degree or above in the high-degree group. In terms of age, referring to the WHO's standard of dividing the boundaries between young people and middle-aged people at 45 years of age, the group under 45 years of age was classified as the young group, and the group over 45 years old was classified as the middle-aged group. In terms of income, the Shenyang per capita annual disposable income of 50,000 yuan was used as the boundary, with those earning below 50,000 yuan classified into the low-income group and those earning 50,000 yuan or above classified into the high-income group. The CFI, TLI, and IFI values in the multigroup analysis model were between 0.9 and 0.95, higher than the standard value of 0.9. The RMSEA values were between 0.034 and 0.046, lower than the optimal threshold of 0.05. This shows that the multigroup analysis model has a good adaptation effect with the sample data. This study focuses on hypotheses H1, H5, and H8a for multigroup analysis (see **Table 8**).

Table 8 shows that in path H1 of the effect of frugality on health accounts, the effect on women is significant ($\beta = -0.086$, $P < 0.01$), while there is no significant effect on men ($\beta = -0.058$, $P > 0.05$), indicating that the more frugality women show, the lower their health accounts. In other words, women's frugal habits have a significant inhibitory effect on their mental accounts of health consumption, but there is no significant inhibitory effect on men. In terms of education, the effect on low-educated people is significant ($\beta = -0.138$, $P < 0.05$) but not on those with higher education ($\beta = -0.008$, $P > 0.05$), indicating that highly educated people are more clearly aware of the role of forest health than less-educated people. Even if they are very frugal, they will set up health accounts, so the effect is not significant. In terms of age, the effect on young people was significant ($\beta = -0.122$, $P < 0.05$), but that on middle-aged people was not ($\beta = -0.046$, $P > 0.05$), indicating that frugal middle-aged and elderly people will still set up higher health accounts. In terms of income, the effect on low-income people was significant ($\beta = -0.097$, $P < 0.05$), but that on high-income people was not ($\beta = -0.015$, $P > 0.05$), indicating that frugal high-income and low-income people set up higher health accounts.

In path H5 of the effect of health accounts on the intention for forest health tourism, the effect is significant for women ($\beta = 0.303$, $P < 0.01$) but not for men ($\beta = 0.162$, $P > 0.05$), indicating that women are more likely to plan consumption expenditures. Once the health account is set low, the intention for forest health tourism is also low. In terms of education, the effect is significant for both the low-educated ($\beta = 0.282$, $P < 0.05$) or high-educated ($\beta = 0.212$, $P < 0.05$) groups. In terms of age, there was a significant effect on the elderly ($\beta = 0.189$, $P < 0.05$) but not on the young ($\beta = 0.239$, $P > 0.05$), indicating that the higher the health accounts established by the elderly are, the stronger their intention for forest health tourism. In terms of income, the effect on low-income people is significant ($\beta = 0.409$, $P < 0.01$), but that on high-income people is not ($\beta = 0.139$, $P > 0.05$), indicating that the lower the health account of low-income people is, the weaker the intention for forest health tourism. Even if the health account of high-income people is

TABLE 7 | Results of multigroup analysis based on cognition, subjective norms, and behavioral attitudes.

Hypothesis path	Public cognition		Subjective norm		Behavioral attitude	
	Low cognition	High cognition	Low norm	High cognition	Negative attitude	Positive attitude
H1: JJ → ZH	−0.154**	−0.052	−0.148**	−0.031	−0.108**	−0.058
H5: ZH → YX	0.245*	0.308**	0.242*	0.446**	0.305*	0.317**
H8a: JJ → YX	0.015	0.024	0.026	0.020	0.007	0.017

*$P < 0.05$, **$P < 0.01$.

TABLE 8 | Results of multigroup analysis based on demographic variables.

Hypothesis path	Gender		Education		Age		Income	
	Male	Female	Low education	High education	Youth	Middle-aged	Low income	High income
H1: JJ → ZH	−0.058	−0.086**	−0.138*	−0.008	−0.122**	−0.046	−0.097*	−0.015
H5: ZH → YX	0.162	0.303**	0.282*	0.212*	0.239	0.189*	0.409**	0.139
H8a: JJ → YX	0.014	0.035	0.041	0.016	0.007	0.052	0.026	0.005

*$P < 0.05$, **$P < 0.01$.

set very low, there is no significant effect on their intention for forest health tourism.

In the influence path H8a of frugality on urban residents' intention to engage in forest health tourism, there was no significant difference between groups, indicating that frugality affects the intention for forest health tourism only through the health accounts for different types of urban residents.

RESEARCH CONCLUSION AND DISCUSSION

Research Conclusion

Based on the theory of planned behavior, mental account theory, and the cognition-attitude-behavior model, this study explored the mechanism by which frugality and cognition affect the intention for forest health tourism, in which health accounts have a complete mediating effect on the relationship between frugality and the intention for forest health tourism, and analyzed the differences of mediating effect of the path "frugality—health accounts—intention" through the grouping of cognition, subjective norms, behavioral attitude, and demographic variables. The conclusions were as follows:

1. Health accounts fully mediate the relationship between frugality and forest health tourism intention, and frugality has a significant negative effect on health accounts, thereby inhibiting forest health tourism intention. However, for urban residents who agree with the role of forest health and hold a positive attitude or are vulnerable to the influence of surrounding relatives and friends, the inhibition of frugality is longer significant.
2. Health accounts and behavioral attitudes play a full mediating role in the relationship between cognition and forest health tourism intention. The higher the urban residents' awareness of the role of forest health are, the higher their health accounts and the stronger their intention to participate in forest health tourism. Health accounts, behavioral attitudes and subjective norms have positive effects on urban residents' intention to engage in forest health tourism; that is, cognition has an indirect positive effect on urban residents' intention to engage in forest health tourism through health accounts and behavioral attitudes.
3. Health accounts have a fully mediating effect on the relationship between frugality and forest health tourism intention, and this effect is moderated by demographic variables such as gender, education, age, and income. The inhibitory effect of frugality on the intention for forest health tourism is no longer significant among male, highly educated, elderly, and high-income urban residents.

Theoretical Contribution

Firstly, this research expanded the application of mental account theory in the study of forest health tourism intention of urban residents. In the previous study of tourists' forest health tourism intention, the theory of planned behavior was singly used to explore the influence mechanism of behavioral intention (Xie et al., 2019), which was relatively weak in explanation. Introducing the concept of frugality and combining the theory of planned behavior with mental account theory, this study analyzed the effect mechanism of frugality and cognition on the forest health tourism intention of urban residents, which not only broadened the application boundary of mental account theory, but also helped to enrich the theoretical system of tourism consumption behavior.

Secondly, in the past, the research on tourism behavioral intention based on the theory of planned behavior (including the extended theory of planned behavior) usually did not provide specific information such as tourist destination and price that affected consumption attitude in the questionnaire explanation, which made it difficult to measure the real consumption attitude and specific behavior intention. On the premise of clearly defining the specific behavior of forest health tourism, this study verified the effect of cognition, behavioral attitude and subjective norms on forest health tourism intention, and further took them as moderating variables to expand the relationship between related concepts of the theory of planned behavior and enhance the comprehensive explanatory power of the theory.

Management Enlightenment

This study introduces the concept of frugality, combines the theory of planned behavior with the theory of mental accounts, and analyses the mechanism by which frugality and cognition affect urban residents' intention to engage in forest health tourism. It not only broadens the application boundary of mental account theory and expands the relationship between related concepts of planned behavior theory but also enriches and improves the theoretical system of tourism consumption behavior. To alleviate the inhibitory effect of frugality, strengthen urban residents' awareness of forest health tourism and promote the development of the forest health industry, this study makes three suggestions:

1. The forest health base, through the continuous enrichment of marketing and publicity, aims to improve the visibility of forest health tourism destinations and strengthen forest health cognition and consumption habits. Forest health tourism is new and has not been widely recognized, and urban residents do not understand its advantages in disease prevention and health care. Therefore, strengthening forest health tourism marketing propaganda is imperative. On the one hand, the forest health base can realize the continuous push of forest health tourism-related information and raise public awareness through various social media (WeChat, Microblog, etc.), short video new media (Tik Tok, Kwai, etc.) and even search engine platforms (Baidu, Google, etc.). On the other hand, middle-aged and elderly people are the main consumers in the forest health tourism market, and their ability to obtain information related to forest health tourism is weak. Most elderly people are still used to traditional media, so it is necessary to increase the propaganda of traditional media such as television advertising and guide young people to buy forest health product packages for their parents from the perspective of children's filial piety to their parents to cultivate middle-aged and elderly people's awareness of forest health and consumption habits.
2. Because frugal consumers are more inclined to make rational use of their money to maximize revenue, forest health tourism bases provide free forest health projects with small investments to enhance the experience value of tourists. For example, only yoga mats and video playback devices are needed for open forest yoga and meditation courses, which will greatly improve consumers' perceived benefits and play an important role in fostering positive attitudes toward forest health tourism and mitigating the negative effect of frugality. At the same time, in the early stage of promotion, the forest health tourism base should increase the benefits of group health and package meals and provide forwarding and recommendation point exchange activities, which can not only increase household consumption but also drive existing consumers to recruit potential consumers via word-of-mouth.
3. Through market segmentation, forest health tourism bases select the target market that matches the supply capacity of enterprises and formulate targeted marketing strategies. The results of multigroup analysis based on demography showed that high education, high income, and middle-aged and elderly male residents were less affected by frugality in the establishment of health accounts. Therefore, the forest health tourism base should target highly educated, high-income, and middle-aged and elderly consumer groups (mainly males) via advertising. First, it should provide a package of forest health tourism products for family consumption by taking the consumption concept of high life quality, high cost-performance ratio, and natural health care over treatment as the starting point and drive the demand for forest health tourism among the relatives and friends of experienced tourists. Second, the forest health base should provide various levels of forest health tourism products and services, including offering fee-based professional courses and free self-help courses for Tai Chi, yoga and meditation enthusiasts to meet the needs of urban residents at various levels of demand.

This study is restricted by many factors and has certain limitations, mainly including the following: (1) To ensure the quality of the questionnaire, this study strictly controlled the quality of questionnaire responses, resulting in a limited number of valid questionnaires. The relevant research conclusions need to be further verified by collecting large sample data from multiple regions. (2) Using a multigroup analysis method, latent variables such as cognition, subjective norms and behavioral attitudes are treated as significant variables, ignoring the measurement error of variables, which may cause an underestimation of the mediation and moderating effects. (3) Since the forest health industry is in the early stage of development, it is difficult to collect relevant data on forest health tourism behavior. This study analyses only the behavioral intention level. In the future, field experimental research methods will be used to study the marketing effect of forest health combined products.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

YL contributed to the conception of the study and helped perform the analysis with constructive discussions. QH performed the experiment, data analysis, and wrote the manuscript. YL and TW contributed significantly to analysis and manuscript preparation. All authors contributed to the article and approved the submitted version.

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Informal Earth Education: Significant Shifts for Environmental Attitude and Knowledge

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Environmental education aims to affect environmental knowledge and attitude to ultimately induce pro-environmental behavior. Based on 247 upper elementary school students, we tested the impact of an outdoor-based earth education program on environmental knowledge and attitude with a pre-post design. Both outcome measures were Rasch scales. Environmental knowledge is a composite of 27 system, action, and effectiveness knowledge items, and environmental attitude is a composite of 13 evaluative statements and 11 self-reported behaviors about nature preservation. Our analysis revealed gains in environmental knowledge and attitude. The convergence between knowledge and attitude increased significantly from pre- to post-program, and attitude played a significant role in knowledge acquisition.

Keywords: earth education, informal learning, environmental attitude, environmental knowledge, Campbell paradigm, Earthkeepers

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INTRODUCTION

For the past decades, the world has been facing increasing environmental challenges of threats, including climate change, resource scarcity, waste accumulation, plastic pollution, and deforestation. Several initiatives attempt to promote environmental awareness and a sustainable lifestyle (UNEP, 1978; UNESCO, 2003), including environmental education at an early age. School curricula have been slow to embrace environmental issues, and short-term interventions in the traditional classroom setting seem to have little impact on long-term pro-environmental shifts, so more intense outdoor programs, such as the Earthkeepers earth education program, become increasingly attractive. Earthkeepers is a 3-day residential earth education program with 1-month or more follow-up activities; it is an informal teaching approach that has shown to result in environmental knowledge and attitude shifts (e.g., Manoli et al., 2007; Johnson and Manoli, 2008; Činčera and Johnson, 2013; Baierl et al., 2021). This study goes a step further than those studies on Earthkeepers to not only test knowledge and attitude shifts but whether they converged over the course of the program, with measurements framed by the Campbell paradigm (e.g., Henn et al., 2019; Baierl et al., 2022), which would support attitude's critical role for knowledge acquisition.

Earthkeepers is an earth education program framed as a "magical learning adventure" developed for upper elementary school students (Van Matre and Johnson, 1988) that originated in the

United States and is implemented in different states and around the world (e.g., Činčera and Johnson, 2013; Baierl et al., 2021). It aims to affect environmental attitude and three types of knowledge (i.e., system, action, and effectiveness knowledge; Frick et al., 2004; Roczen et al., 2014) through a 3-day holistic outdoor experience and 1-month or more follow-up activities, with the goal of participants becoming more inclined to pro-environmental engagement. In the program, participants can earn four *keys* to unlock the secrets of becoming an Earthkeeper, the word itself being an acronym for the main components of the program (knowledge, experience, yourself, and sharing). During the initial 3 days at the outdoor center, learners engage in participatory activities to learn about four ecological concepts, namely, energy flow, cycling of materials, interrelationships, and change, and to experience the natural world to earn the K and E keys. Back at home and school, participants work on lessening their impact on and deepening their feelings for the environment to earn the Y key, and they also share their experiences with others to earn the S key and become Earthkeepers. Teachers and parents support the participants in documenting behavior changes and provide evidence that they engaged in lessening their impact and deepening feelings for at least 1 month, with the idea that doing something regularly for that long can form new habits. The program thus resonates with a long tradition of sustainability education, which aims at balancing knowledge, attitudes, and practices to guide students toward sustainability (Salas-Zapata et al., 2018). Several studies of the Earthkeepers program report knowledge gains (e.g., Činčera and Johnson, 2013; Manoli et al., 2014) and positive attitude changes in 4–6 weeks after the residential program (e.g., Manoli et al., 2007, 2014; Baierl et al., 2021). Earthkeepers thus show promising potential to foster long-term pro-environmental shifts.

There is a growing research body on the environmental knowledge-attitude relationship framed by the Campbell paradigm that points at attitude's role in knowledge acquisition (e.g., Kaiser and Frick, 2002; Frick et al., 2004; Roczen et al., 2014; Henn et al., 2019; Baierl et al., 2022). Within the Campbell paradigm, one can derive an attitude through self-reported behaviors or opinion-based statements by confining to their underlying goal, rendering goals reflections of attitudes (Kaiser and Wilson, 2019). One behavior can be fueled by several goals (Kaiser, 2021): People could refrain from single-use plastic bags because (1) there is a charge on it, (2) they are inclined toward environmental preservation, or (3) in some countries, it might be socially proscribed to use such bags. Scales should therefore ask for a variety of opinions and behaviors to disentangle an underlying attitude (Kaiser, 2021); in this study, i.e., environmental attitude, which reflects a person's commitment to nature preservation that becomes manifest in protective behaviors or expressions of support for nature preservation. Such behaviors and opinions come with behavioral costs. Costs are the obstacles a person overcomes to carry out behavior, and those are resources, such as time, money, or energy. Reading books and other materials about environmental preservation requires all three of those resources and is, therefore, a behavior that comes with high costs, whereas separating waste from recyclables requires neither money nor a lot of time if done on a regular basis and if the cultural setting provides for it (e.g., government supplying free garbage bins). Costs can thus be imposed by societal constraints or infrastructure (money, time, effort, convenience, or social expectations) and strongly relate to culture, so ecological behavior is not stable but context-dependent, and behaviors can be ordered in terms of costs (Kaiser et al., 2010). We can therefore assume that people agree with increasingly demanding behaviors in a way that is congruent with their attitude. If a person rejects low-cost behaviors, such as reusing shopping bags or turning off the light when it is needed no more, we can conclude a weak environmental attitude. On the contrary, if a person buys products in refillable packages or with eco-labels and contributes to environmental organizations, we can expect a rather strong attitude.

With a Campbellian perspective on attitude that differentiates behaviors in regard to their costs and people's likelihood of engagement in increasingly costly behaviors, attitude's role in learning, i.e., knowledge acquisition as the behavior, becomes more apparent. Then, an attitude affects (1) the probability and (2) the intensity of engaging in learning activities, with knowledge as a somewhat measurable outcome (Henn et al., 2019; Baierl et al., 2022). Following this logic, learning activities can lower costs in two ways: First, through the provision of information, students do not need to make an effort and actively seek information; second, through presenting information in an appealing and exciting way (e.g., acknowledging learning theories, such as the cognitive load theory) that reduce costs (Chandler and Sweller, 1991). It requires, e.g., more cognitive resources if a complex environmental issue is presented in a small-print, long text (i.e., concentration is required to disentangle essential information) than when it is sequenced in blocks, reduced to its essentials, and some information is substituted or embellished by visuals like graphs or pictures. In a Campbellian sense, it would require a stronger attitude to engage in such a small-print, long text, whereas a visually engaging text can capture low-attitude students when the educational goal is to impart and acquire information.

However, information is not all the same but can be separated in system, action, and effectiveness knowledge (Frick et al., 2004; Roczen et al., 2014). System knowledge (i.e., procedural knowledge; Schultz, 2002) corresponds with facts or conceptual understanding (Frick et al., 2004), and in this case, can be knowledge about ecological systems or information on human impact on Earth (Díaz-Siefer et al., 2015). Building on system knowledge, action knowledge covers behavioral choices. A person could know about climate change, e.g., the effects of rising CO_2 and CH_4 levels in the atmosphere (system knowledge) but lack knowledge about climate-friendly actions, such as using public transportation instead of your car (action knowledge). Effectiveness knowledge is on a higher level and asks for general gains and environmental benefits. It points at broader impacts (Schultz, 2002) through concepts, such as saving energy and reducing carbon emissions on a larger scale like political regulations, so those could be ordered hierarchically regarding their effectiveness (Frick et al., 2004). All those categories form environmental knowledge, and, synergistically, they can help guide toward environmental preservation. The Earthkeepers program incorporates this framework of

environmental knowledge, and in this study, we aim to relate it to environmental attitudes.

RESEARCH QUESTIONS

Using a shorter, more practicable version of Baierl et al.'s (2022) scale, which is a Rasch-calibrated compilation of expressions of opinions about nature preservation (Bogner and Wiseman, 1999) and self-reported behaviors to preserve the environment (Kaiser et al., 2007), this study investigated the following questions:

(1) How do knowledge and attitude scores change after participation in the earth education program Earthkeepers?
(2) How do knowledge and attitude scores relate over the course of the Earthkeepers program (T1 = before and T2 = 4–6 weeks after the 3-day residential course)?

MATERIALS AND METHODS

Participants and Procedure

Participants consisted of 247 upper elementary school students (age $M \pm SD$: 9.38 ± 0.51; $n = 235$, 12 students provided no information on age). School classes in the Tucson area in Arizona, United States, visited the earth education center to participate in the Earthkeepers program as part of their education, so participation was not voluntary for students. Gender showed an almost even distribution with 54.7% ($n = 135$) of females and 41.3% ($n = 102$) of males; 10 students provided no information on gender. All participants completed the paper-and-pencil questionnaire 1–2 weeks before (T1) and 4–6 weeks after (T2) the 3-day Earthkeepers program in Arizona, United States. The students experienced nature holistically on-site (i.e., using their senses to tune in on nature, or inquiry-based hands-on explorations) and learned about their natural environment (e.g., system knowledge: how nutrients cycle, action knowledge: the environmental impact of importing fruits, and effectiveness knowledge: hierarchically listing which common electric devices use most fossil fuels). Following the on-site program, educators helped the students put the newly learned knowledge into practice by choosing at least *one behavior* to reduce their energy consumption (e.g., using a bicycle instead of getting a ride by car) and at least *one behavior* to reduce their material use (e.g., re-using paper that has already been used on one site, or taking a shower instead of a bath). The students were encouraged to implement those individual behaviors for at least 1 month after the residential course and to document whether they met their goals in their training manual. Their parents were introduced to the manual and received a four-page explanation on the Earthkeepers and its follow-up tasks. Those tasks referred to the individual behavior changes and nature experiences, so the students were encouraged to regularly spend time outdoors and reflect on their experiences as well as reduce their energy and material use. The manual provided space for the students to document their behavior changes and for recording their thoughts on their nature experiences. Parents then signed whether those things were done, and the teachers talked to the students about the manual. Teachers and parents thus provided evidence that the participants engaged in pro-environmental behavior for at least 1 month after the residential course, and most participants earned the final keys (Y and S) as part of program completion. This helps investigate long-term effects. Since control groups have repeatedly shown no significant changes in knowledge or attitude while Earthkeepers participants did (Johnson and Manoli, 2008; Činčera and Johnson, 2013; Baierl et al., 2021), a control group was not used in this study.

Measures

We are interested in environmental knowledge, environmental attitude, and their relationship. Therefore, we used an environmental knowledge and attitude scale.

Environmental Knowledge

The scale contained 27 items and covered system, action, and effectiveness knowledge (Frick et al., 2004). In total, 13 items involved facts and concepts about our natural environment, such as how energy flows and the materials cycle. Based on this, five action knowledge items asked about behavior options to turn system knowledge into practice: People can, e.g., know about plastic pollution but to protect nature, they further need to know which behaviors reduce their plastic share. In addition, nine effectiveness knowledge items covered the efficiency of conservation behaviors. Studies showed that all three dimensions are helpful for pro-environmental engagement and that all three dimensions work synergistically (e.g., Roczen et al., 2014), so we merged them for our analyses. The participants answered in a multiple-choice format with three to four answer options. For system knowledge, there was one correct answer to gain one point per item. For action and effectiveness knowledge and in line with a partial-credit model, participants could further gain half-points for a good but not the best answer. For the question "Which item is less harmful for the environment to consume?," participants gained no point for ticking "farm-raised meat," half a point for "farm-raised veggies," and one point for "homegrown foods" (see item 11 and all other knowledge items in the **Supplementary Table 1**).

We conducted a Rasch analysis for all 27 items (Rasch, 1980 or Wilson, 2005; for computational details, see Adams and Khoo, 2015). The person separation reliability by Wright and Masters (1982) estimates the ratio between actual performance (observed behavior) minus the mean square errors of those estimates and the variance of behavior scores; it indicates that our scale was acceptable ($rel = 0.63$). Item difficulties (δ) showed an even distribution from –2.27 to 2.24 with the mean arbitrarily set at zero ($M = 0.00$, $SD = 1.03$). Person parameters ranged from –1.44 to 3.09 ($M = 0.56$, $SD = 0.80$). Negative numbers indicate easier items and lower person estimation scores, while the higher the number, the more challenging an item or the higher the probability of that particular person to give the correct answer is (Bond and Fox, 2007). A person's ability score of 0 indicates that a person is likely to answer 50% of all questions correctly. For item fit assessment, mean square values (MS) show the correspondence between our

data and the Rasch-model prediction, and infit MS should fall between $0.80 \leq MS \leq 1.20$ (Bond and Fox, 2007); MS thus indicate the discrepancy between the model's prediction and the observed data. The knowledge items ranged from the value of MS as 0.86 to 1.27, so they were well within or close to the threshold. For an exhaustive list of items and fit indices, refer to **Supplementary Table 1**.

Environmental attitude was assessed using 13 items from Bogner and Wiseman's (1999) scale modified for use with children in the United States (Johnson and Manoli, 2008) and 11 items from Kaiser et al.'s (2007) scale. The item compilation covers opinions about nature preservation (i.e., evaluative statements) and self-reports of past preservation-relevant engagement, and is jointly used to measure environmental attitude. It has been suggested to collapse attitudinal instruments within the Campbell paradigm to one dimension, disregarding whether they relied on evaluative statements or self-reported behaviors (e.g., Kaiser et al., 2013; Kaiser and Wilson, 2019), and Baierl et al. (2022) did so with Bogner and Wiseman's (1999) and Kaiser et al.'s (2007) scales without the need of a predefined fix set of items; both instruments seem to complement each other as Bogner and Wiseman's (1999) scale contains items that are easier to agree with (people only have to agree with expressions about nature preservation, which requires on average fewer costs) and Kaiser et al.'s (2007) scale contains preservation-based items that are more demanding (people have to actually perform pro-environmental behaviors, which requires on average more costs), so we tested a shorter and slightly modified version for use with children in the United States.

Our attitude measure consisted of 24 items and was calibrated using the dichotomous Rasch model (Rasch, 1980; Wilson, 2005). The participants responded to each item on a five-point frequency scale ranging from strongly disagree to strongly agree (Bogner and Wiseman, 1999) or never to always (Kaiser et al., 2007), and we reverse-coded six negatively formulated items reflecting an environmentally harmful tendency before the analysis (**Supplementary Table 2**). We dichotomized those polytomous items with strongly disagree, disagree, and not sure/neutral, or never, seldom, and occasionally representing a low-attitude level, while agree and strongly agree, as well as often and always represent a high-attitude level. Collapsing polytomous scales to a dichotomous format is a well-justified approach to prevent excessive measurement error, particularly in attitude research (Matell and Jacoby, 1971; DeCoster et al., 2009). This way, we assessed environmental attitude through personal parameters, and the higher the score, the stronger the probability for environmental preservation-related engagement—a representation of environmental attitude. Scores ranged from –2.35 to 3.73 ($M = 0.60$, $SD = 1.01$). The separation reliability was reasonably accurate ($rel = 0.73$), and item fit statistics showed a fair model fit with MS ranging from 0.9 to 1.16. Item difficulties (δ) ranged from –1.58 to 2.5, and their perceived costs aligned with previous studies, e.g., trying to persuade parents to buy an energy-efficient car as a rather demanding, and taking a shower instead of a bath as a more effortless behavior (e.g., Kaiser et al., 2007; for all items and further fit statistics, **Supplementary Table 2**).

Statistical Analysis

Our data were not normally distributed; since tests of the Statistical Program for Social Sciences (SPSS, 24 version) yielded identical results for all (non-) parametric calculations, we report parametric outcomes to be consistent with most studies having used these instruments. The *T*-tests were used to identify program effects, correlations were used for trends, and regression analyses were used for investigating attitude effects on knowledge (gains) and their convergence. We further used a Rasch model (Maximum-likelihood estimates) and dichotomized the five-point frequency scale for attitude (Rasch, 1980; Wilson, 2005). The probabilistic Rasch measurement acknowledges individual engagement (number of items answered positively) and item difficulty (number of people answering to an item positively) and allocates each participant a score (Bond and Fox, 2007). To conduct the Rasch analysis, we used the software ConQuest (Adams and Khoo, 2015).

RESULTS

Promotion of Environmental Knowledge and Attitude

Between T1 and T2, knowledge levels increased, and a *T*-test confirmed statistically significant gains (pre: $M = 0.368$, $SD = 0.67$, 95% CI: 0.28–0.45; post: $M = 0.751$, $SD = 0.88$, 95% CI: 0.65–0.87; $p < 0.001$, $d = 0.49$, $n = 246$). A similar pattern, though the increase was not as large, occurred for environmental attitude (pre: $M = 0.495$, $SD = 0.86$, 95% CI: 0.37–0.59; post: $M = 0.706$, $SD = 1.12$, CI: 0.57–0.85; $p = 0.001$, $d = 0.22$, $n = 244$; **Figure 1**). There were no considerable gender differences.

Environmental Attitude as a Lever for Knowledge Acquisition

We correlated knowledge and attitude scores before the program and after the program completion. While both correlations were statistically significant (pre scores: $r = 0.189$, $p = 0.003$, $n = 246$ and post scores: $r = 0.391$, $p < 0.001$, $n = 244$), knowledge and attitude scores correlated significantly stronger after the intervention ($z = -2.438$, $p = 0.007$), which indicates that knowledge and attitude scores converged between T1 and T2. This speaks for a synergistic effect with attitude promoting knowledge acquisition; participants with a stronger pro-environmental mindset seem more likely to learn and to learn more intensely about nature and environmental preservation.

Therefore, we corroborated the dependence of knowledge on attitude levels by conducting a multiple regression analysis. The model showed a high goodness-of-fit ($R^2 = 0.239$; adjusted $R^2 = 0.233$; Cohen, 1988). Both knowledge levels before the intervention and attitude levels were statistically significant predictors of post-knowledge scores: $F(2, 242) = 38.05$, $p < 0.001$. While prior knowledge appeared to be the stronger predictor ($\beta = 0.455$, $p < 0.001$), attitude levels also showed a statistically significant effect ($\beta = 0.114$, $p = 0.045$) on the participants' post-program knowledge scores. We then regressed knowledge gains on environmental attitude, which revealed a statistically

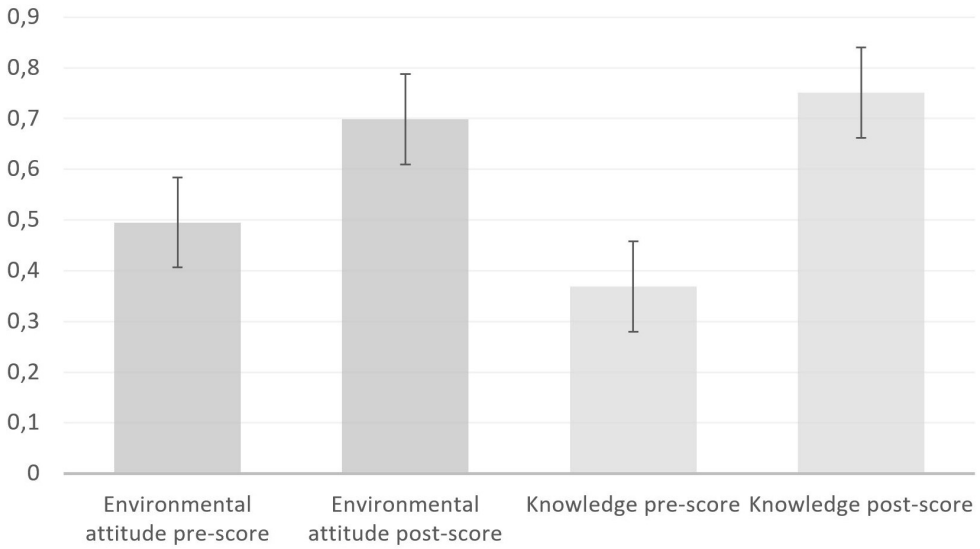

FIGURE 1 | Program effects were statistically significant for environmental attitude and knowledge; error bars indicate 95% confidence intervals. The data were assessed 1 week before and 6–8 weeks after the residential earth education program to determine long-term changes. The *Y*-axis gives the Rasch calibration output, and the higher the score, the more knowledge is prevalent or the stronger the attitude is.

significant effect of attitude on the knowledge participants gained and retained between T1 and T2: $\beta = 0.229$; $F(1, 242) = 13.45$, $p < 0.001$; $R^2 = 0.049$ (**Figure 2**).

To further test attitude's role in knowledge acqisition, we tested the role of attitude changes in knowledge gains (i.e., post-program attitude scores minus attitude scores before the program), which turned out to be statistically significant: $\beta = 0.176$; $F(1, 241) = 7.68$, $p = 0.006$; $R^2 = 0.027$. We then tested the effect of prior knowledge scores on attitude changes ($\beta = 0.102$), which indicated that attitude increases did not depend on what students knew at the beginning of the program, so attitude gains were not significantly related to prior knowledge levels: $F(1, 242) = 2.56$, $p = 0.111$; $R^2 = 0.049$. Quite the opposite, i.e., increases in environmental attitudes seemed to promote knowledge gains.

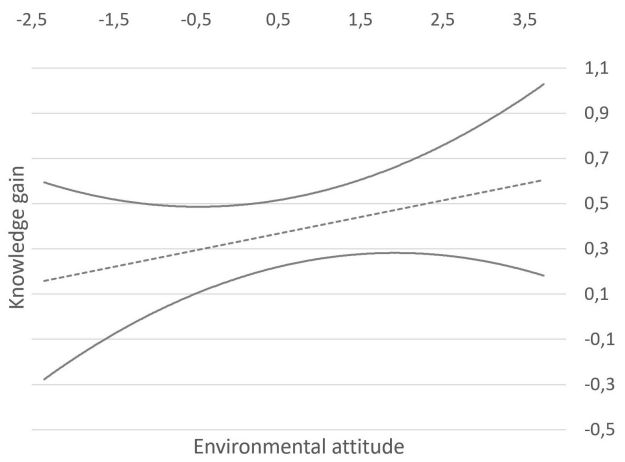

FIGURE 2 | Environmental knowledge gains after the Earthkeepers program regressed on environmental attitude. Their relationship is depicted in the dashed upward trend line. Bold lines show the 95% confidence interval. Both scales are based on a Rasch calibration, so the higher the score, the more knowledge students gained and the stronger the attitude is.

DISCUSSION

We applied an abbreviated version of Baierl et al.'s (2022) proposed scale that builds on opinion-based expressions to preserve the environment and self-reported preservation-related behaviors to jointly capture environmental attitudes. Our analysis confirmed that environmental attitude's sound assessment does not depend on a specific set of verbal statements but can be retrieved from various self-reported opinions and behaviors about nature preservation framed by the Campbell paradigm (Kaiser and Wilson, 2019), even with children in a particular environmental setting (i.e., Arizona desert). Based on the scale's sound calibration, results indicated that it was sensitive to pro-environmental shifts in participants in an earth education program and valuable to knowledge acquisition.

Effects of the Earth Education Program Earthkeepers

Participants showed pro-environmental shifts in environmental knowledge and attitude 6–8 weeks after the 3-day outdoor earth education program and its one-month follow-up activities. The participants gained and retained knowledge about the environment—a composite of understandings (e.g., how materials cycle and energy flows), knowledge about environmentally friendly behavior options (e.g., how to save water and energy), and general strategies for nature preservation

(e.g., how consumer choices affect carbon emissions or waste accumulation). This is in line with previous studies of the Earthkeepers program in different US states and countries (e.g., Činčera and Johnson, 2013; Manoli et al., 2014; Baierl et al., 2021), indicating the outdoor experience and back-in-classroom activities were beneficial in engaging participants in knowledge acquisition. This might be even more important in a society that is faced with growing environmental issues while there is an alienation from nature (Hinds and Sparks, 2008). Pyle (1993, 2003) labeed, and Soga and Gaston (2016) restated and emphasized this trend as the extinction of experience and thus voice the importance of (re-) connecting with nature. This is linked to attitude; pro-environmental shifts can be induced when individuals encounter nature and a sense of connectedness, guided by teachers and parents as role models (Rickinson, 2001; Schultz et al., 2004). Indeed, attitude levels increased over the course of the Earthkeepers program, including not only changes in opinions about nature preservation (assessed *via* evaluative statements) but also became apparent in more frequent environmental engagement (assessed *via* self-reported individual behaviors). Participants changed their perceptions of and engagement in nature preservation. This is underlined by the high rate of participants who earned the Y key, an indicator of frequent pro-environmental engagement based on the newly learned information. Pro-environmental shifts in knowledge and attitude were persistent weeks after program completion, corresponding with other studies about intensive outdoor initiatives (e.g., Bradley et al., 1999; Duerden and Witt, 2010; Fančovičová and Prokop, 2011).

Knowledge and Attitude Convergence

Environmental knowledge and attitude levels converged over the course of the program, which is before and 4–6 weeks after the on-site course, and further analyses indicated that attitude was a key factor for knowledge acquisition. Though knowledge scores before the program contributed more to knowledge scores after program completion, attitude also turned out to be a significant predictor. It is well known that prior knowledge contributes to gains and retention of topic-related information. Multiple learning theories regard previous knowledge as the basis for effectively gaining new information; e.g., new information is integrated with and linked to pre-existing one, which helps information bridging short to long-term memory (e.g., Chandler and Sweller, 1991). Other theories suggest any sort of knowledge can serve as anchors for new information, even if that knowledge might be, from a scientific view, incorrect. In educational settings, misconceptions can even be integrated into the classroom work to serve as a basis for modification toward scientific more correct information (e.g., White and Gunstone, 1989).

Less apparent is attitude's role in knowledge acquisition, which is thought to help overcome behavioral costs and thus increase engagement in learning activities, while it further controls the intensity with which participants learn and thus how much knowledge people gain and retain (Henn et al., 2020; Baierl et al., 2022). Our analysis points at both roles of attitude in knowledge acquisition; the stronger the attitude, the more knowledge participants knew before and after the program and the more knowledge participants gained. In a multilevel regression analysis, in addition to prior knowledge, attitude turned out to be a significant predictor of post-program knowledge scores. The stronger the environmentally-conscious attitude, the more participants knew, learned, and retained about the environment. Further robustness tests revealed that increases in attitude scores affected knowledge gains, while prior knowledge scores were statistically insignificant for attitude gains. Although knowledge is a main goal of environmental education, this points to organizing environmental education programs in a way to strengthen attitudes so knowledge follows. This shifts the focus to the question of how environmental attitude can be best promoted, so environmental knowledge follows. The Earthkeepers program seems to be a platform to promote participants' environmental attitudes, though more research is required as to how attitudes are promoted and how to translate such promotion into the traditional classroom setting.

Study Limitations

Since we asked for self-reports, social desirability could have affected our findings. However, the original scales have been shown to be resistant to social desirability (e.g., Kaiser, 1998; Oerke and Bogner, 2013). In this study, teachers let participants know that the questionnaires were neither graded nor evaluated. Instead, the questionnaires were filled in anonymously, and the teachers did not look at them but put them in envelopes. Second, though we focused on one outdoor environmental learning center in Arizona, we merged different classes that might have been exposed to different conditions. We tried to compensate by compiling a large dataset to determine general trends. Third, parents and teachers kept track and ultimately signed whether students engaged pro-environmentally and whether they reflected on their nature experiences. This way, as a social contextual factor, parent and teacher involvement might have affected attitude shifts (e.g., Gifford and Nilsson, 2014). Finally, though there have been several studies that found significant program effects in knowledge or attitude in Earthkeepers participants, while control groups showed no such effects, we can only draw assumptions because our study lacked a control group.

CONCLUSION

With an environmental attitude measure that builds on preservation-relevant evaluative statements and behavioral self-reports, we were able to document pro-environmental shifts toward more environmentally positive perceptions and a higher frequency of pro-environmental engagement based on the 3-day residential earth education program Earthkeepers with at least 1 month of follow-up activities. The sound assessment of nature preservation, i.e., environmental attitude, does not require a fixed

set of items but appears flexible in terms of length, age-groups, and modifications to the specific environment participants encounter, given the composite of opinion- and behavior-based self-reports framed by the Campbell paradigm. Knowledge levels, a composite of facts, understandings, and knowledge about behavior options and general ecological strategies, also increased significantly. Knowledge and attitude levels converged, and in addition to prior knowledge, attitude accounted for post-program knowledge scores, shifting the focus of environmental education programs to strengthening attitudes. This is further supported by a regression analysis showing that the higher the attitude level, the more knowledge participants gained and retained over the course of the Earthkeepers program, which has been demonstrated to be an effective platform for promoting environmental knowledge and attitude.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article can be made available by the authors on request, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

T-MB contributed to the conceptualization, methodology, formal analysis, writing the original draft, and visualization. BJ contributed to the resources and writing, reviewing, and editing the manuscript. FB contributed to the writing, reviewing, and editing the manuscript and supervision. All authors have read and agreed to the published version of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.819899/full#supplementary-material

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Cross-Cultural Awareness and Attitudes Toward Threatened Animal Species

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The preservation of our planet's decreasing biodiversity is a global challenge. Human attitudes and preferences toward animals have profound impacts on conservation policies and decisions. To date, the vast majority of studies about human attitudes and concern toward animals have focused largely on *western, educated, industrialized, rich* and *democratic* (i.e., WEIRD) populations. In order to mitigate biodiversity loss globally, an understanding of how humans make decisions about animals from multicultural perspectives is needed. The present study examines familiarity, liking and endorsement of government protection amongst six broad cultural groups living in Qatar for five threatened animal species indigenous to the Arabian Gulf. Our findings highlight similarities and differences across cultures toward animals. Overall, familiarity did not predict endorsement for government protection after liking was accounted for. Liking, however, emerged as an important predictor of endorsement for government protection across cultures, although the degree of animal liking varied culturally. WEIRD and South East Asian participants showed similar and more positive attitudes toward animals compared to the other groups. Participants from the Arabian Gulf, Sub-Saharan Africa, Middle East and North Africa, and South Asia responded similarly toward the animals. Interestingly, the Arabian Gulf group demonstrated significantly less liking and protection endorsement for animals, including those animals which play an important role in their culture. This research highlights intriguing avenues for future research and points to liking as a possible universal human attitude toward animals that influences decision making about conservation across all cultures while suggesting applications for improving education.

Keywords: culture, animal, attitudes, liking, familiarity, conservation, Qatar, Arabian Gulf

On aime ce qui nous a émerveillé, et on protège ce que l'on aime. - Jacques Cousteau

In the end we will conserve only what we love. We will love only what we understand. We will understand only what we are taught. - Baba Dioum

INTRODUCTION

The rapid loss of biodiversity on our planet is a global challenge. According to the International Union for Conservation of Nature Red List (IUCN), the number of animals worldwide that are added to endangered and critically endangered lists is rapidly increasing (International Union for Conservation of Nature, 2021). Biodiversity loss is overwhelmingly accelerated by humans, who are altering the planet at an unprecedented rate (Steg and Vlek, 2009; Secretariat of the Convention on Biological Diversity, 2020; WWF, 2020).

Reversing biodiversity loss requires a holistic and representative understanding of human attitudes and behavior toward animals across all cultural perspectives. Because animal conservation is a global issue, it is necessary to understand human behavior collectively. However, investigations of human attitudes toward animals have been predominantly conducted with WEIRD (*western, educated, industrialized*, *rich, democratic*) populations (e.g., Amiot and Bastian, 2014), or have explored attitudes toward animals in isolated cultural contexts with regionally-specific questions (e.g., Heinen and Shrivastava, 2009; McLennan and Hill, 2012; Buckley et al., 2017). Research on the influence of human attitudes toward animals and effects on policy clearly demonstrate how human preferences for certain types of animals influence decision making and policies related to conservation efforts (Coursey, 1994; Metrick and Weitzman, 1996; Czech et al., 1998; Knegtering et al., 2002; Tisdell et al., 2005; Mahoney, 2009; Tisdell, 2014); however, these studies are limited in their global reach. Thus, scientists, policymakers and educators need to understand how all people decide the worth of animals. This understanding can be leveraged to improve people's perception of animals and in turn to nudge behavior and decision making in support of biodiversity initiatives. More concretely, this knowledge can aid in the development of conservation programs for global audiences. One promising avenue of research is to determine if there are psychological universals related to human attitudes toward animals that might be leveraged to empower global policymakers, educators and scientists to create overarching global mitigation strategies (i.e., Norenzayan and Heine, 2005). To empower these stakeholders, cross-cultural research needs to explore important questions including how humans decide the worth of animals, how these decisions relate to perceived need for protection for animals, and how these decisions influence human behavior and government policy.

One method researchers have employed to investigate the relationship between attitudes toward conservation and biodiversity is the willingness-to-pay (WTP) procedure (Martín-López et al., 2007; Tsi et al., 2008; Wang and Jia, 2012; Echeverri et al., 2017; Dörge et al., 2022). The WTP procedure when used to study attitudes toward animals assumes that people will pay for the conservation of an animal according to their perceptions of that animal's worth, typically in the form of a monetary donation to support conservation. The definition of worth is largely subjective, and may include many criteria such as aesthetic, emotional, economic and scientific factors. This paradigm allows researchers to explore which factors motivate decision making around individual conservation behaviors.

Using intended donations as a measure for conservation intentions in the general population, Echeverri et al. (2017) asked Canadian undergraduates how much they liked, were familiar with and would be willing to donate to conserve four endangered North American animals. Participants' subjective familiarity with an animal correlated positively with liking for each animal, suggesting that the more subjects felt they knew about a particular animal, the more they liked them. Familiarity was found to be unrelated to one's intention to donate for conservation, whereas liking emerged as a significant predictor of participants' WTP for an animal's conservation. These results suggest that although knowledge leads to more positive attitudes toward animals, it is the positive attitude, not the knowledge, that results in pro-conservation intentions toward animals. Beliefs about endangered status only influenced intended donations for the most liked and least liked animals in the study. In a follow-up study (*Ibid*), the researchers asked American and Indian M-Turk participants about their familiarity, liking and WTP for the same animals. Once again, subjective familiarity was positively related to liking. Liking again predicted intended donations for all animals; however, familiarity also emerged as a significant predictor of intended donations for three of the four animals. Thus, the role of liking and familiarity were not uniform across these two studies. One reason for this finding may be related to culture; however, the authors did not analyze the results of their study by culture, so it is not possible to know if culture played a role in the findings.

Martín-López et al. (2007) surveyed Spanish and European National Park visitors on animal preference and measured their WTP for 15 species native to the National Park (they also included 5 plant species). Participants differed on their motivations to visit the park, and these motivations were related to tendencies to think about animals from different perspectives. For example, short-term visitors tended to view animals on utility and familiarity, whereas nature enthusiasts and environmental professionals had stronger stances related to ethics and ecological-scientific considerations. All visitors ranked animals in a similar order, indicating strong positive attitudes toward megafauna, and ranked birds highest overall, followed by mammals, reptiles, fish, and invertebrates. Overwhelmingly, the authors found affective factors (i.e., animal liking), more strongly influenced WTP than economic factors or scientific considerations, especially amongst visitors with less knowledge and concern about environmental issues. Knowledge and education about biodiversity issues did moderate the results for visitors with expert knowledge about the animals, suggesting an important role for specific education on these issues.

In France, Colléony et al. (2017) measured actual donations as part of an animal adoption program given for endangered zoo animals, against the type of animal adopted, animal charisma, phylogenetic distance from humans, IUCN threat level and the order the animal appeared alphabetically in the adoption list. Animals with higher charisma ratings were more likely to be adopted, although they received less funding than non-charismatic animals, suggesting that those people who

chose less charismatic animals more thoughtfully participated in the adoption program. Interestingly, adoption of a non-charismatic animal did not correlate with biodiversity concern. Additionally, animals that appeared at the beginning of the alphabetically ordered adoption list were also more likely to be adopted, suggesting participants employed a cognitive shortcut to make their adoption decision. Finally, the IUCN threat level of the animal had no influence on animal adoption. Similarly, in a survey of Slovak zoos, Fančovičová et al. (2021) found zoo donations to be influenced most strongly by animal attractiveness and phylogenetic closeness to humans, where threat status only played a small role compared to animal factors. These findings highlight the possibility that people take a simple and biased approach to animal conservation decisions, picking animals which are most liked and most readily available. It is important to underline potential differences between paradigms that measure intended versus actual donations to animal conservation. For example, in Germany Dörge et al. (2022) measured both intended and actual donations to insects. Though all respondents were favorable toward insect conservation, a significant intention-behavior gap was found in their response patterns, where their intentions to donate to insect conservation were larger than their actual donations. These findings suggest that using the willingness to pay procedure has some limitations when drawing conclusions about how people will actually behave (also see Kanya et al., 2019).

Results from studies employing the WTP procedure comparing different types of animals highlight how personal preferences toward animals have a stronger impact on decision making than knowledge about the animals or endangered status in the general population (for further discussion see: Gunnthorsdottir, 2001; Marešová and Frynta, 2008; however, for different perspectives see Tisdell, 2014). The notion that people are willing to pay more for certain types of animals is in line with research on flagship species (Clucas et al., 2008; Small, 2012). Flagship species are popular, charismatic animals that serve as symbols for acquiring public support to promote conservation awareness and action. Examples of flagship species include the giant panda (*Ailuropoda melanoleuca*), the tiger (*Panthera tigris*) or the African elephant (*Loxodonta africana*), all of which have subjective charm or a defining, appealing characteristic (Ducarme et al., 2013). Due to their perceived charisma, flagship species can generate increased conservation donations (e.g., Bowen-Jones and Entwistle, 2002; Fazey et al., 2005; Sitas et al., 2009), and play a crucial role in conservation programs, though this comes with both advantages and disadvantages (see Ducarme et al., 2013). Overall, charismatic species are typically large mammals and vertebrates who possess something people value as attractive and/or positive, such as intelligence, beauty, valor, singularity or strong symbolism.

Taking into consideration the role that human attitudes in western contexts play in conservation behavior and that these attitudes are moderated by preferences for animals, it is therefore important to understand to what degree, if any, human attitudes toward animals vary across cultures (Norenzayan and Heine, 2005). Arguably, animal charisma is subjective and differences in animal liking may be reasonably assumed to exist across cultures. Indeed, culture has been demonstrated to have important consequences for broader conservation attitudes, where interactions with religion, childhood experiences, diet, gender and age have been found to shape thought (e.g., Busch et al., 2020; Randler et al., 2021); however, even in broader contexts related to human-environment interactions, the literature lacks cross-cultural investigations (Tam and Milfont, 2020).

The present study aims to address these attitudes in a multi-cultural context in Qatar, a small, rich peninsular state in the Arabian Gulf. Qatar's terrestrial habitat is arid desert and the coastline is long, shallow and warm. Compared to WEIRD countries, Qatar is arguably *Educated*, *Industrialized* and *Rich*, but it is neither *Western* nor *Democratic*. Its population is extraordinarily multicultural. Approximately 85% of Qatar's population are expatriates. Qatar does not have an immigration policy, so foreigners living in Qatar stay only for the duration of their work visas (a few months to 20+ years). In part because there is limited long term immigration in the country, there is little mixing between citizens and expatriates, and people tend to maintain close ties to their home cultures and traditions. Estimated population demographics reveal the rich nature of the multi-cultural environment in Qatar: Indian nationals are the most prevalent group (22%), followed by Nepalese and Bangladeshi (13%), other Arab (13%), Filipino (7%), Pakistani (4%) and Sri Lankan (5%), and interestingly, Qatari nationals (11%) are a minority in their own country. The percentage of WEIRD foreigners is around 5%. The vast majority of people in Qatar (>90%) live in the capital city, Doha (Snoj, 2019).

We launched a nation-wide survey to query citizens and expatriates (residents) about their awareness and attitudes toward five threatened species indigenous to the Arabian Gulf region. The present study is unique in that it measured attitudes toward threatened species across a diverse range of cultures all living in the same geographical area, and compared these attitudes to the most commonly investigated WEIRD population. Many of the participants are citizens of countries which have not been previously studied with regard to awareness and attitudes toward animals and conservation. In order to understand basic awareness of the animals, we first asked participants to indicate their degree of familiarity with each animal, followed by whether or not they liked the animal. We then asked participants to which degree they endorsed the animal for government protection. We replaced willingness to pay with willingness to endorse government action in order to avoid potential cultural confounds related to perceptions and attitudes toward charity. Specifically, culture is a source of psychological and behavioral variation, and thus, the concept of charity may be culturally variable (e.g., Norenzayan and Heine, 2005). In addition, there is a wide disparity between income levels in Qatar, so the meaning of a donation amount will not be consistent across groups.

We investigated three main questions. First, do participants from different cultural groups rank animals with the same order preference? This question is interesting to explore in light of many findings which suggest that humans have particular affinity for certain animals (e.g., typically mammals) and less for others (e.g., typically reptiles) and to determine if these biases generalize across cultures. If culture impacts relative preferences for animals, we expect to discover significant variability in the patterns of liking across cultures.

Second, do people from diverse cultures have different attitudes with regard to familiarity, liking and endorsement for government protection toward threatened animals in Qatar? As there is little previous literature to predict whether or not cultural differences in familiarity, liking and endorsement for conservation will emerge, we investigated cultural questions from an exploratory stance. However, if culture plays a role, we expect Arabian Gulf participants to have a closer relationship to some of our species studied due to the role the species have in their culture.

Third, what is the likely mechanism that leads people to endorse government protection for threatened animals? Existing literature (e.g., Colléony et al., 2017; Echeverri et al., 2017) led us to predict that an individual's willingness to endorse an animal for conservation will be mediated by animal liking, over and above familiarity. If this relationship can be demonstrated cross-culturally, it can help improve policy decisions and guide future research into successful interventions supporting animal conservation.

MATERIALS AND METHODS

This paper reports findings from a nation-wide survey in Qatar that was approved by the Carnegie Mellon University in Qatar (CMU-Q) local Institutional Review Board (Protocol #1603679-3). Data were collected between February 22 and April 9, 2021. Facebook and Instagram advertisements targeted Qatari residents and citizens who were 18 years of age or above. While scrolling through their Facebook/Instagram newsfeeds, potential participants were invited to "Volunteer to support research about awareness of Qatar's natural heritage" and presented with a post containing the study flyer, information sheet, and a link to the online survey. All recruitment materials were provided in both Arabic and English. If participants wished to participate in the study, the link directed them to CMU-Q's Qualtrics platform. Participants could then choose to take the survey in Arabic or in English. The survey consisted of three sections.

The first section included the Nature Relatedness Scale-6 (Nisbet and Zelenski, 2013) and modified questions about moral stances toward nature (Graham et al., 2009). The questions about moral stances explored participants' views around protecting and treating animals fairly, agency in protecting animals, and the role of institutions in supporting protection. In the current set of analyses, these items were used as control variables and will be presented in a separate paper.

The second section asked participants to answer three questions about a diverse subset of threatened and indigenous species to Qatar and the Arabian Gulf. Participants were not told during the study that the animals were threatened. The five animals were chosen from the IUCN Red List for threatened and endangered species and because they are indigenous to Qatar, which means that Qatar's government, citizens and residents play a critical role in conservation of these species:

- The dugong (*Dugong dugon)*, a close relative of the manatee and commonly referred to as a sea cow, is a relatively large marine mammal which is found in Qatar's shallow coastal waters. The resident dugong population is the second largest population in the world after Australia (Preen, 2004; Marshall et al., 2018). Dugongs are threatened in Qatar mainly due to their slow reproduction, destruction of their coastal habitat, sea sport, commercial fishing, and pollution (Marsh and United Nations Environment Programme, 2002; Rabaoui et al., 2021). According to the IUCN, the dugong is vulnerable with decreasing status (Marsh and Sobtzick, 2019).
- The whale shark (*Rhincodon typus*), the world's largest fish, appears between April and September about 90 km off Qatar's coastline to feed on plankton and tuna eggs (Robinson et al., 2013). Observations indicate that the Arabian Gulf is home to one of the world's largest gatherings of whale sharks (Bach and Al-Jaidah, 2012; Robinson et al., 2013) as it offers an abundance of food due to the unique marine characteristics of the region (Bach et al., 2014; Robinson et al., 2017). The whale shark's life cycle and migration habits are poorly understood; therefore, its conservation requires global efforts. It is currently listed as endangered and decreasing (Pierce and Norman, 2016).
- The hawksbill sea turtle (*Eretmochelys imbricata*), a reptile, is the only sea turtle that nests in Qatar. Nesting occurs along Qatar's eastern coastline between April and June (Chatting et al., 2018). About 200 sea turtles nest each year in three sites in Qatar, as well as other sites in the Arabian Gulf (Pilcher et al., 2014). The hawksbill sea turtle is listed as critically endangered with a decreasing status (Mortimer and Donnelly, 2008). In the Arabian Gulf, the hawksbill sea turtle faces threats due to rapid coastal expansion, widespread loss of marine habitat and climate change (Marshall et al., 2020).
- The saker falcon (*Falco cherrug)* is undergoing a rapid decline and is listed as endangered and decreasing by the IUCN (BirdLife International, 2021). The saker falcon is Qatar's national bird and plays an important role in Qatar's cultural heritage. Traditionally, the saker falcon had been used to hunt and is still used by locals for recreational hunting in all the Arabian Gulf states. The species faces threats due to trapping of birds for recreational use, pollution and habitat destruction.
- The spiny-tailed agama, locally known as Dhub (*Uromastyx aegyptia)*, is currently listed as vulnerable and decreasing by the IUCN (Wilms et al., 2012). It is a burrowing lizard that lives in loose colonies and feeds on low vegetation. This reptile is found on the Arabian Peninsula and throughout the Arabian Gulf countries such as parts of Egypt, Iraq, Iran and Jordan. It faces threats due to habitat loss from land reclamation, overgrazing, pollution and quarrying.

Participants were asked about each animal in succession in a randomized order. A color photograph of the animal was displayed, followed by these three questions:

1. Are you familiar with the <animal>?
2. How much, if at all, do you like the <animal>?
3. How much, if at all, do you think the government should prioritize protection of the <animal>?

Participants were given the following four-point Likert scale to respond to question 1: I do not recognize this animal;

A little; Somewhat; A lot. Questions 2 and 3 were not presented if participants said they did not recognize the animal. For those respondents who indicated some degree of recognition, a four-point Likert scale with the following options was presented for questions 2 and 3: Not at all; A little; Somewhat; A lot.

In the final section of the survey, participants were asked their age, gender, nationality they most strongly identified with; highest level of education obtained and years living in Qatar.

A total of 3,418 social media users clicked on the link to our survey. Of these, 244 did not meet the inclusion criteria and 582 respondents did not complete the survey. Overall, a representative sample of 2,612 citizens and residents of Qatar completed the survey. From these, 218 participants chose not to divulge their nationality and are therefore not considered in the present analysis. **Table 1** presents the demographics according to gender, age, education and years in Qatar of the remaining 2,394 respondents. Officially in Qatar, only 25% of the population is female; however, in our survey 47.8% of respondents were female. The official gender imbalance is skewed due to a large influx of foreign male laborers for construction projects. It is likely that the laborers did not participate in our survey, perhaps due to language barriers or disinterest. Participant ages ranged from 18 to over 81 years of age. The majority of the respondents were between the ages of 18–40 (84.5%) years of age. Those who participated were educated, with 78.3% of respondents indicating education beyond high school. Finally, reflecting the expatriate nature of many of Qatar's residents, 28.1% of participants resided in Qatar for less than 5 years and a further 53.36% indicated living in Qatar between 5 and 20 years.

Overall, respondents hailed from 96 unique nationalities (see **Table 2**). The most frequent nationality was Indian (31.7%), followed by Qatari (10.9%), Pakistani (7.8%) and Filipino/a (5.8%). This distribution is representative of the multi-cultural population in Qatar. For example, Indian nationals make up the largest percentage of any nationality living in Qatar at 21.9%, Pakistani nationals are estimated at 4.7%, Filipino/a nationalities at 7.4%, and Qataris at 10.5%. Note, Qatari nationals are a minority in Qatar (Snoj, 2019).

For data analysis, survey respondents were divided into six groups based on the nationality they most strongly identified with (**Table 2**): (a) Arabian Gulf ($n = 273$); (b) Middle East and North Africa (MENA, excluding Arabian Gulf; $n = 505$); (c) South Asia ($n = 1{,}065$); (d) South East Asia (S. East Asia, $n = 176$); (e) Sub-Saharan Africa (Africa, $n = 125$); and (f) WEIRD ($n = 172$). The WEIRD group was formed by combining nationalities from North America, Western Europe, Australia and New Zealand and has been previously described in the literature (Henrich et al., 2010; Klein et al., 2018). The remaining groups were created using the same regional criteria from the United Nations, Economic and Global Affairs, Statistics Division for use in the Sustainable Development Goals (SDG) indicators (United Nations Statistics Division, 2022). We divided the Arabian Gulf as a separate group from the MENA group in order to have more fine-grained analysis of the local population. We understand that there are variations in cultures within these large groupings, however based on other studies and on regional proximity, we feel that these are meaningful cultural groups. A group of "Mixed" participants was created ($n = 78$) which included participants from cultures and countries for which we did not have sufficient data to form regional groups, and for which we expected to see no systematic variation in animal preferences and attitudes based on the assumption that culture influences response patterns. Response rate by gender varied significantly across groups, with high female response rates in the Arabian Gulf, South East Asian, WEIRD and the Mixed groups. Interestingly, more males than females responded in the MENA and Sub-Saharan African groups. The WEIRD group tended to be older and more educated than the other groups, and the Arabian Gulf was the youngest group on average. MENA participants lived in Qatar for a similar

TABLE 1 | Descriptive statistics for demographic characteristics.

	Characteristics	Number of respondents	Percentage
Gender	Female	1,140	47.76
	Male	1,229	51.49
	Prefer not to say	18	0.75
Age	18–22	463	19.36
	23–30	805	33.65
	31–40	753	31.48
	41–50	275	11.50
	51–60	79	3.30
	61–70	13	0.54
	71–80	2	0.08
	81+	2	0.08
Education	Elementary school or less	23	0.97
	High school graduate	494	20.73
	College/Vocational/ Associate's degree	275	11.54
	Bachelor's degree	1,070	44.90
	Master's degree	439	18.42
	Professional degree (e.g., MD, JD, DD)	44	1.85
	PhD or other Doctoral degree	38	1.59
Years in Qatar	Less than 5	665	28.09
	5–10	649	27.42
	11–20	614	25.94
	21–30	290	12.25
	31–40	89	3.76
	41–50	43	1.82
	51–60	13	0.55
	61–70	0	0.00
	71+	4	0.17

Of the total 2,394 respondents used in our analysis, 2,387 answered the question about gender, 2,392 reported their age, 2,383 responded to the question about education, and 2,367 answered how long they had lived in Qatar.

TABLE 2 | Country names (respondent number) by regional group and associated group percentage of female respondents, median age, median education and median years in Qatar.

Group name (N)	Country (n)	% Female	Median age	Median education	Median years in Qatar
Arabian Gulf (273)	Qatar (261), United Arab Emirates (3), Saudi Arabia (4), Bahrain (1), Oman (3), Kuwait (1)	72	23–30	Bachelor's Degree	21–30
MENA (505)	Algeria (25), Egypt (97), Iran (9), Iraq (5), Jordan (68), Lebanon (29), Libya (4), Morocco (16), Palestine (36), Sudan (95), Syria (47), Tunisia (42), Turkey (9), Yemen (23)	44	31–40	Bachelor's Degree	11–20
Sub- Saharan Africa (125)	Burkina Faso (1), Cape Verde (1), Eritrea (6), Ethiopia (1), Ghana (5), Kenya (50), Mauritania (1), Mauritius (3), Mozambique (1), Nigeria (18), Somalia (9), South Africa (17), Tanzania (1), Uganda (10), Zimbabwe (1)	35	31–40	College/Vocational/ Associate's degree	5–10
South Asia (1,065)	Afghanistan (2), Bangladesh (60), India (758), Nepal (10), Pakistan (186), Sri Lanka (49)	36	23–30	Bachelor's Degree	5–10
South East Asia (176)	Indonesia (18), Malaysia (14), Myanmar (1), Philippines (138), Singapore (5)	73	31–40	Bachelor's Degree	5–10
WEIRD (172)	Australia (9), Austria (1), England (59), Canada (17), France (19), Germany (7), Ireland (8), Italy (7), Netherlands (1), New Zealand (2), Norway (1), Portugal (5), Scotland (4), Spain (6), Switzerland (1), Wales (2), USA (23)	63	31–40	Bachelor's Degree	5–10
Mixed (78)	Albania (4), Argentina (1), Armenia (1), Azerbaijan (1), Belarus (1), Bosnia and Herzegovina (1), Brazil (6), Chile (1), China (3), Colombia (7), Costa Rica (2), Croatia (2), Estonia (1), Georgia (1), Greece (5), Hungary (1), Japan (2), Kazakhstan (3), Kyrgyzstan (4), Mexico (7), Peru (1), Poland (2), Romania (7), Russia (2), Serbia (1), South Korea (1), Suriname (1), Tonga (1), Tajikistan (1), Trinidad and Tobago (1), Ukraine (5), Venezuela (1)	79	31–40	Bachelor's Degree	Less than 5

number of years as their age, suggesting that many members of this group may have been born in Qatar. The other groups had spent significantly less time in the country, suggesting they were more transient expatriates.

Of the three main questions, first, we ask do participants from different cultural groups rank animals with the same order preference? To answer this question, we provide descriptive statistics for each cultural group's preference rank. Besides, we conduct paired *t*-tests for ranking preferences to understand mean differences between the ranked animals by group.

Second, do people from diverse cultures have different attitudes toward threatened animals in Qatar? To address our second question, we implement a series of linear regression analyses where we consider three dependent variables: familiarity, liking, and endorsement of government protection, respectively. Our control variables include gender, age, education, years lived in Qatar, nature-relatedness scores (NR-6; Nisbet and Zelenski, 2013), and moral stances toward nature (based on Graham et al., 2009) as these variables could be correlated with the dependent variables and cultural backgrounds. Given the discrete nature of our dependent variables, we also run a series of ordered logistic regression analyses to ensure that our substantive conclusions were robust to different model choices.

Third, what is the likely mechanism that leads people to endorse government protection for threatened animals? To address our third question, we examine how participants' familiarity with and liking of the threatened animals influence their endorsement of government protection for the animal. By answering this question, we aim to deepen our understanding of how the three different types of attitudes toward endangered animals are related. Our analysis for this question consists of two parts. First, we run three linear regression models to compare the effects of familiarity and liking on the endorsement of government protection. Second, we build on the linear regression analysis results to hypothesize a mechanism about how familiarity and liking influence the endorsement of government protection. To test our hypothesis, we use the potential outcomes approach to causal mediation analysis (Imai et al., 2010a,b) and the mediation R package (Tingley et al., 2014). This approach clarifies the identification assumptions required to estimate the mediation and the direct effects. Furthermore, it allows researchers to conduct a sensitivity analysis so that they can assess how much the estimated effect would be influenced by a possible violation of the assumptions.

RESULTS

Ranking of Animal Preferences by Cultural Group

Figure 1 depicts the ranked order from most to least preferred animal across country groups. To summarize, each of the groups demonstrated clear animal preferences, and the order of animal preference follows a similar pattern across groups. The hawksbill sea turtle (T) is ranked or tied for first place as the preferred animal for each group, with the exception of South Asia, where it ranked second. The whale shark (W) and the dugong (D) are consistently grouped together in the rankings of each country group (i.e., they do not differ significantly from each other), except for the South Asian group. The spiny-tailed agama (A) was ranked significantly lowest by each cultural group, however note this difference was less pronounced in the WEIRD group.

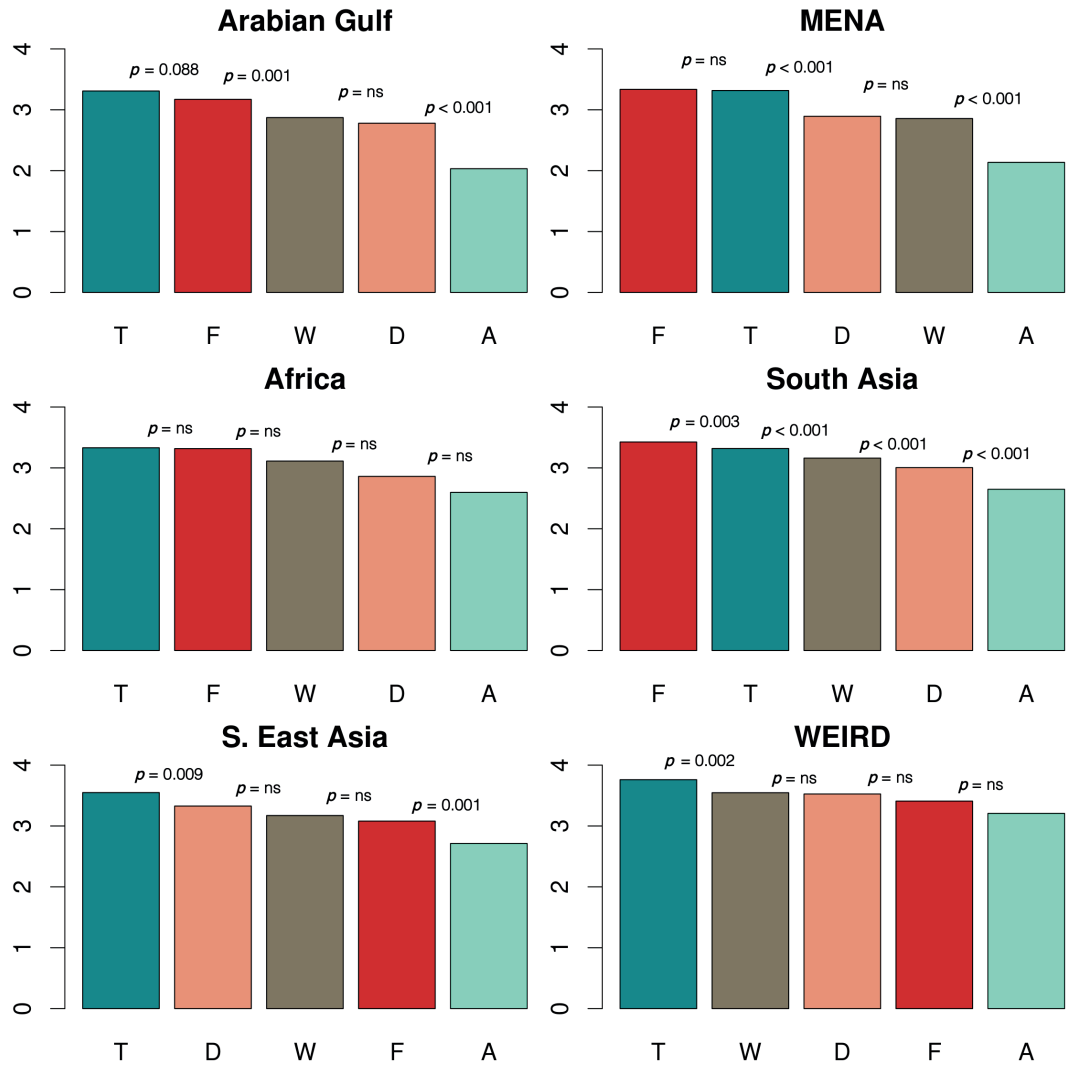

FIGURE 1 | Ranking of Animal Preferences by Culture. D = Dugong. W=Whale shark. T = H.S. Turtle. F = S. Falcon, A = S.T. Agama. *p*: *p*-values from paired *t*-tests. ns: not significant at 0.05.

Only the saker falcon (F) shows meaningful rank differences across groups.

Figure 1 also depicts the paired *t*-tests' *p*-values for the mean differences between the ranked animals by group. For instance, in the top left panel for the Arabian Gulf group the value of $p = 0.088$ reflects the mean difference between the hawksbill sea turtle and the saker falcon. Below, we interpret the paired *t*-test results briefly at the 0.05 significance level and detailed analysis is provided in **Supplementary Figure S1**.

The Arabian Gulf group's preferences and the MENA group's preferences are identical from a statistical point of view. The hawksbill sea turtle and the saker falcon are grouped together at the top of the ranking. The dugong was ranked significantly lower than the hawksbill sea turtle, but does not differ significantly from the whale shark. Finally, the spiny-tailed agama is liked the least.

Although none of the pairs for the African group's mean difference tests reveal a significant difference at the 0.05 level, overall, it appears that the African group's preferences are similar to the Arabian Gulf and MENA groups' preferences. Similarly, the South Asian group's overall pattern is more or less similar to the Arabian Gulf and MENA groups' patterns, while the South Asian group's rankings for the five animals are all significantly different.

Finally, the South East Asian group's preferences and the WEIRD group's preferences are similar to each other. Both groups like the hawksbill sea turtle significantly more than the other animals. The dugong, whale shark, and saker falcon are grouped together in second place. While the South East Asian group's relative dislike for the spiny-tailed agama over the other animals is statistically significant, the WEIRD group's tendency to rank the spiny-tailed agama lower than the saker falcon is short of statistical significance.

Do Attitudes Toward Threatened Species Differ Across Cultures?

To address our second question, we implemented a series of linear regression analyses and a series of ordered logistic regression analyses to ensure that our substantive conclusions were robust to different model choices. We found that the substantive conclusions derived from the ordered logistic models were identical to the conclusions based on our linear regression models. Thus, we focus here on the results from our linear regression models without loss of generality; the ordered logistic estimation results can be found in **Supplementary Figure S2**.

Figure 2 depicts the linear regression results for each animal across cultures for familiarity (Panel A), liking (Panel B) and endorsement of government protection (Panel C). For each of the models, the WEIRD group was used as a baseline (set to zero and depicted by the red dotted line) for comparison and effect sizes with 95% confidence intervals (CIs) are shown. If a group's 95% CI does not cross the red dotted line, it means that the group is significantly different from the WEIRD group at the 0.05 significance level. We chose the WEIRD group as the baseline without loss of generality. Our substantive conclusions do not change when the baseline group varies. In order to make sense of the effect sizes, we can consider the following example. Panel A plots the country groups' familiarity ratings for each animal. With respect to the dugong, the effect size value for the Arabian Gulf participants (depicted by the black square) is −0.64, which represents the difference between the Arabian Gulf group and the baseline WEIRD group for familiarity with the dugong. Thus, respondents from the Arabian Gulf are predicted to be less familiar with the dugong than the WEIRD group by 0.64, where the value of 1 means one level in the measurement used. This measurement was in response to the question "*Are you familiar with the < animal >?*" and used the Likert scale which ranged from 1 ("I do not recognize this animal") to 4 ("a lot"). In contrast, if we examine the familiarity plot for the spiny-tailed agama (Panel A, far right), the Arabian Gulf respondents are predicted to be much more familiar with the spiny-tailed agama than the WEIRD group by about 1 Likert scale point (approximately 0.92).

Overall, the linear regression results demonstrate cultural differences for familiarity, liking and endorsement of government protection. Panel A reveals respondents from the Arabian Gulf and MENA regions, and to some degree Sub-Saharan Africa indicated increased familiarity for the saker falcon [Arabian Gulf: $t(2,375) = 4.54$, $p < 0.000$; MENA: $t(2,375) = 3.37$, $p = 0.001$; Africa: $t(2,375) = 3.27$, $p = 0.001$] and spiny-tailed agama [Arabian Gulf: $t(2,372) = 8.27$, $p < 0.000$; MENA: $t(2,372) = 3.82$, $p < 0.000$; Africa: $t(2,372) = 1.74$, $p = 0.082$] compared to the WEIRD group. All other groups indicated less familiarity with the dugong [Arabian Gulf: $t(2,373) = -5.76$, $p < 0.000$; MENA: $t(2,373) = -9.63$, $p < 0.000$; Africa: $t(2,373) = -6.53$, $p < 0.000$; South Asia: $t(2,373) = -9.70$, $p < 0.000$] and the hawksbill sea turtle [Arabian Gulf: $t(2,372) = -3.02$, $p = 0.003$; MENA: $t(2,372) = -4.80$, $p < 0.000$; Africa: $t(2,372) = -4.54$, $p < 0.000$; South Asia: $t(2,372) = -4.98$, $p < 0.000$] than WEIRD participants, except for South East Asians who indicated more familiarity with the dugong than the WEIRD group [$t(2,373) = 4.94$, $p < 0.000$]. For the whale shark, the MENA [$t(2,373) = -3.63$, $p < 0.000$] and Sub-Saharan Africa [$t(2,373) = -1.97$, $p = 0.049$] groups were significantly less familiar with the it than the WEIRD group, and the South East Asians were significantly more familiar with the whale shark than WEIRD participants [$t(2,373) = 3.76$, $p < 0.000$].

Panel B in **Figure 2** depicts the linear regression results for each animal across cultures for liking. Generally, WEIRD participants showed a trend of increased animal liking compared to the other groups (p-values range from 0.000 to 0.044), except for the dugong for which the South East Asian and the WEIRD participants do not differ significantly [$t(1,579) = 0.278$, $p = 0.781$] and the saker falcon for which the South Asian and the WEIRD groups do not differ [$t(2,257) = 1.47$, $p = 0.143$]. Examining the 95% CIs, it is clear that the WEIRD group behaves exceptionally: most of the other groups do not differ significantly from one another with regards to animal liking. It is striking that the Arabian Gulf group does not like the saker falcon [$t(2,257) = -2.89$, $p = 0.004$] or spiny-tailed agama [$t(1,549) = -6.81$, $p < 0.000$] more than WEIRD participants, considering the high familiarity (see Panel A) and the cultural significance of these animals.

Finally, Panel C depicts the linear regression results for each animal across cultures for endorsement of government protection, our proxy for the WTP procedure used in other studies. The Arabian Gulf participants endorsed all of the animals less for protection than WEIRD participants [dugong: $t(1,573) = -1.98$, $p = 0.048$; whale shark: $t(2,216) = -3.60$, $p = 0.000$; hawksbill sea turtle: $t(2,127) = -2.18$, $p = 0.029$; saker falcon: $t(2,246) = -2.25$, $p = 0.025$; spiny-tailed agama: $t(1,540) = -4.44$, $p < 0.000$]. MENA and South Asian participants behaved similarly, endorsing all animals, except the saker falcon, less for protection than WEIRD participants [*MENA*: dugong: $t(1,573) = -3.14$, $p = 0.002$; whale shark: $t(2,216) = -4.83$, $p < 0.000$; hawksbill sea turtle: $t(2,127) = -2.43$, $p = 0.01$; spiny-tailed agama: $t(1,540) = -4.32$, $p < 0.000$. *South Asia*: dugong: $t(1,573) = -2.55$, $p = 0.011$; whale shark: $t(2,216) = -2.39$, $p = 0.017$; hawksbill sea turtle: $t(2,127) = -2.60$, $p = 0.009$; spiny-tailed agama: $t(1,540) = -3.11$, $p = 0.002$]. South East Asian and Sub-Saharan African participants did not differ from the WEIRD group, except in the case of the dugong, where South East Asians were more likely to endorse it for protection [$t(1,573) = 2.15$, $p = 0.032$].

Which Mechanism Might Lead to Endorsement of Government Protection for Threatened Animals?

To address our third question, we examined how participants' familiarity with and liking of the threatened animals influence their endorsement of government protection for the animal. By answering this question, we aim to deepen our understanding of how the three different types of attitudes toward endangered animals are related.

First, we ran three linear regression models to compare the effects of familiarity and liking on the endorsement of

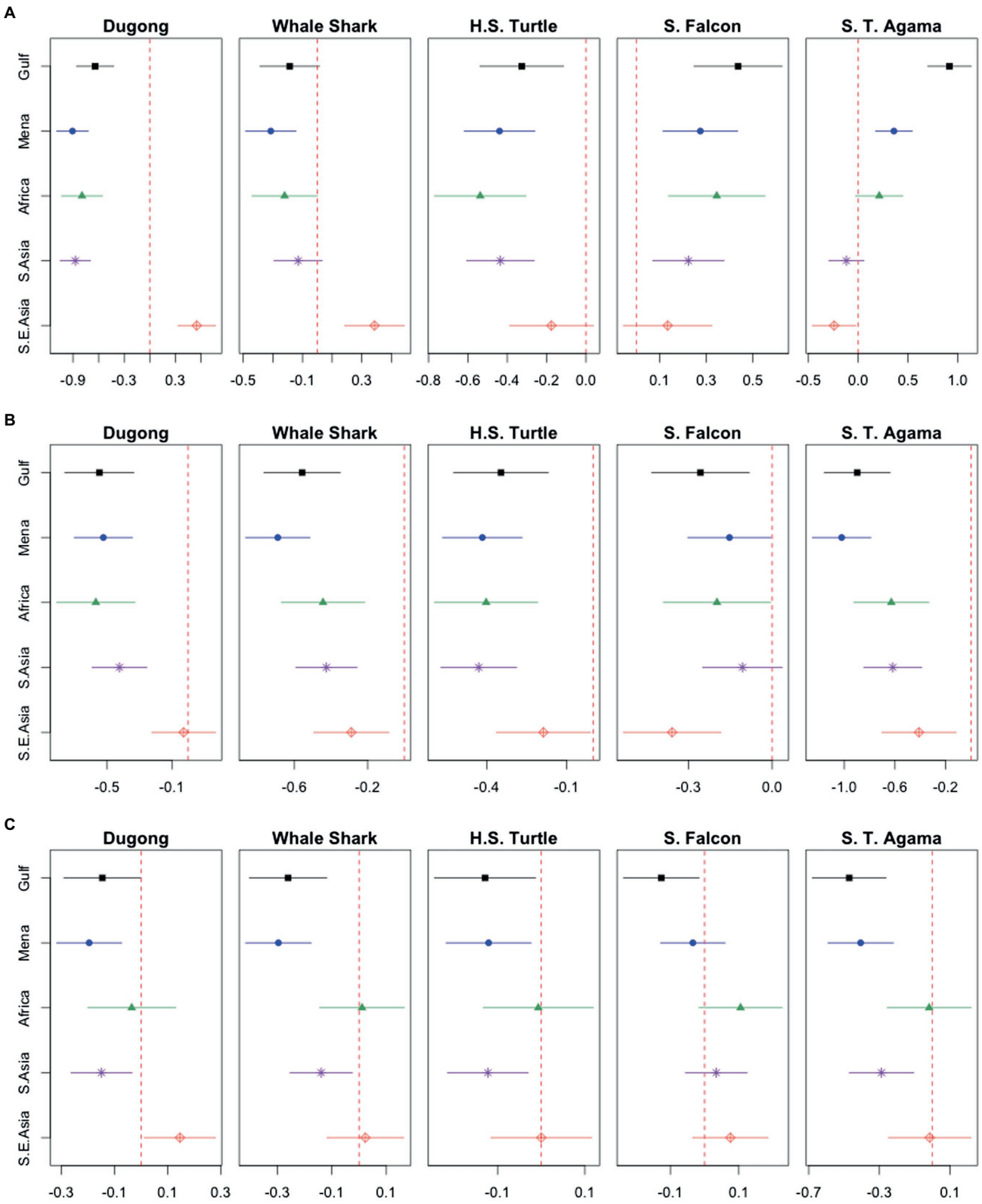

FIGURE 2 | Ordinary least squares coefficients and 95% confidence intervals (CI): Comparing different nationalities. The red dotted line in each plot indicates the baseline WEIRD group. If a certain group's 95% CI does not cross the red dotted line, it means that the group is significantly different from the WEIRD group at the 0.05 significance level. The "Mixed" group is omitted from the plot for the sake of simplicity though it is included in the analyses. Panel **(A)**: familiarity. Panel **(B)**: liking. Panel **(C)**: endorsement of government protection.

government protection. **Figure 3** displays our regression analysis results. Each of the five plots displays the ordinary least squares coefficients and 95% CIs that come from three different linear regression models. In Model 1 and Model 2, we investigate the relationship between familiarity and endorsement and the relationship between liking and endorsement, respectively. Model 3 includes both familiarity and liking as predictors for the endorsement of government protection.[1]

In order to introduce **Figure 3**, let us take the example of the dugong: the black square and the black line in the plot for the dugong indicate the estimated effect of familiarity with the dugong on the endorsement of government protection for the animal and its 95% CIs. These are derived from Model 1 where only the variable for familiarity, along with the control variables, are included. On the other hand, the green square and the green line in the same plot represent Model 3's familiarity variable.

Most notably, the results suggest that the effect of familiarity diminishes significantly after accounting for liking, whereas the effect of liking remains virtually the same after accounting for familiarity. Continuing to use the dugong example, the estimated effect of familiarity is about 0.11, and it is statistically distinguishable from zero at the 0.05 level according to Model 1 [$t(1,530) = 5.92$, $p < 0.000$]. However, the estimated effect shrinks to about 0.014, and it is no longer different from zero at the 0.05 level according to Model 3 [$t(1,524) = 0.69$, $p = 0.490$]. Similar patterns appear in the other animal cases such that the effect of familiarity weakens significantly after the variable for liking is also considered. In contrast, the estimated effect of liking obtained from Model 2 does not significantly decline after controlling for familiarity in Model 3. For example, the blue circle in the dugong case indicates that the estimated effect of liking is about 0.229 [$t(1,527) = 14.00$, $p < 0.000$] in Model 2. The green circle in the same plot reveals that the estimated effect of liking is about 0.225 [$t(1,524) = 12.64$, $p < 0.000$] after the variable for familiarity is included in Model 3.

These results allow us to better understand how the three types of attitudes toward threatened animals are related. First, the extent to which participants are familiar with a threatened animal does not uniquely explain their endorsement of government protection for the animal. Rather, the amount of variance in the endorsement of government protection explained by familiarity mostly overlaps with what liking explains. Second, although familiarity and liking are correlated and jointly explain the endorsement of government protection, liking explains a large amount of unique variance in the endorsement of government protection that familiarity cannot explain.

We continued to build on the above results to delve further into the relationship between the three types of attitudes toward threatened animals. Our finding that familiarity does not uniquely explain participants' endorsement of government protection while liking does might be due to the mediating role of liking between familiarity and the endorsement of government protection. In other words, the effect of familiarity with an animal on the endorsement of government protection might exert mostly *via* how much they like the animal.

In **Figure 4**, the mediation effect graphically illustrates our hypothesis, which suggests that the extent to which participants like the animal mediates the effect of familiarity on the endorsement of government protection. This hypothetical

[1]The three models' control variables are consistent with the control variables used in the previous subsection. Full regression analysis results are available in **Supplementary Tables S1-S5**.

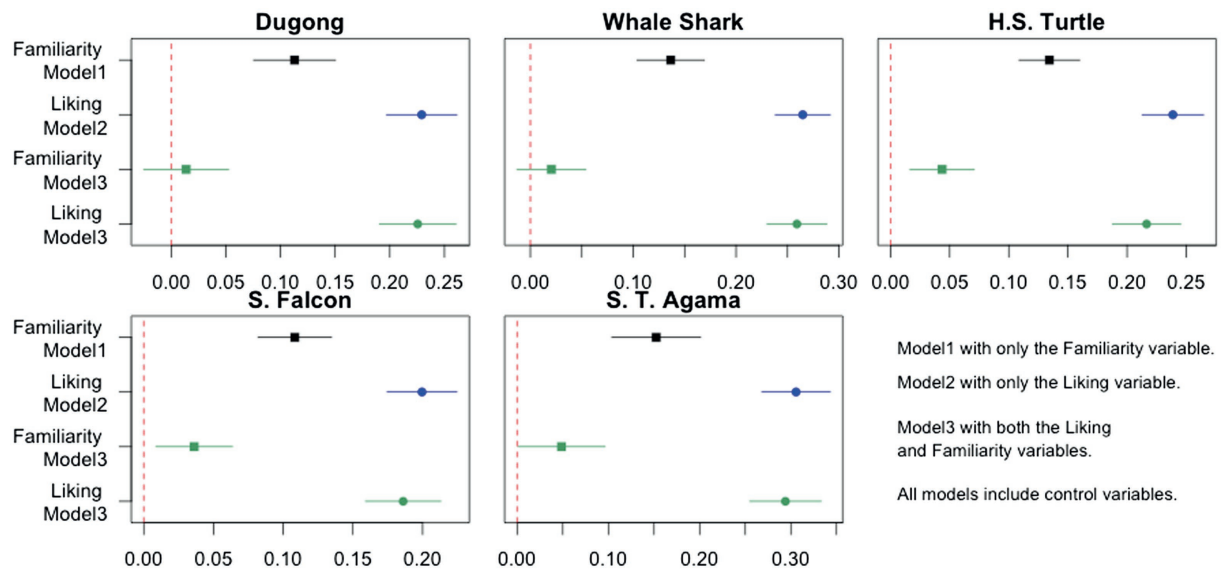

FIGURE 3 | Ordinary least squares coefficients and 95% confidence intervals: Comparing the effects of familiarity and liking on the endorsement of government protection.

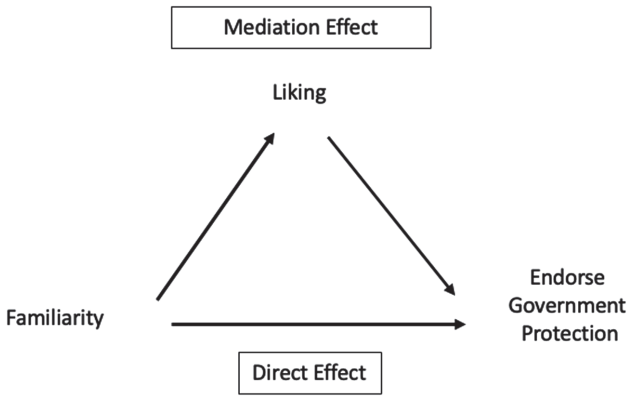

FIGURE 4 | Model. The total effect of familiarity on the extent to which people endorse government protection is decomposed into two causal pathways. The top pathway reflects a mechanism through which the effect of the extent to which people are familiar with the threatened animal is mediated by how much they like the animal. The bottom direct pathway between familiarity and endorsement represents alternative mechanisms not intervened by how much they like the animal.

mechanism suggests that the more familiar with the animal people are, the more they like the animal, and once they like the animal, they tend to endorse government protection for the animal.

The bottom pathway in **Figure 4** captures all other mechanisms not intervened by our hypothetical mechanism. We call this pathway the direct effect of familiarity on the endorsement of government protection. The total effect of familiarity on the endorsement of government protection is the sum of the mediation effect and the direct effect.

We build on the potential outcomes approach to causal mediation analysis (Imai et al., 2010a,b) to test our hypothesis. We made two assumptions to identify the mediation and direct effects in our analysis, following the sequential ignorability assumption proposed by Imai et al. (2010b). First, we assume familiarity is independent of potential outcomes for endorsement of government protection and liking, after controlling for pretreatment covariates. Since the extent to which people are familiar with an animal is based on their knowledge, we are less concerned about the possibility that people's subjective liking or endorsement of government protection affects familiarity. Nevertheless, individual characteristics associated with liking could be correlated with familiarity. Hence, we control for demographic characteristics, nature-relatedness, and moral stances toward nature as pretreatment covariates to minimize contamination from individual characteristics.

The second assumption is that the extent to which people like a threatened animal is independent of potential outcomes for endorsement of government protection given the observed pretreatment covariates and the observed values for familiarity. Similar to the first assumption, this assumption would be violated if individual characteristics associated with endorsing government protection are correlated with familiarity or liking. Thus, we included the same pretreatment covariates as in the previous analyses to minimize a possible violation of the assumption. Additionally, we implemented a sensitivity analysis to ensure that a possible violation of the first and second assumptions would not significantly change our analysis results. The results of the sensitivity analysis can be found in **Supplementary Figure S3**.

We used the mediation R package (Tingley et al., 2014). The mediation package performs a mediation analysis based on two steps. The first step fits two regression models. To begin with, we fit the model for the mediating variable--liking. The right-hand side of this model includes the treatment variable--familiarity and pretreatment covariates. We also fit the model for the outcome variable--endorsement, in which the right-hand side variables include the same variables as the first model and additionally the mediating variable. The pretreatment covariates used in each of these two models are demographic characteristics (age, gender, and education), the composite measure of nature-relatedness, and the seven variables for moral stances toward nature. Thereafter, the second step computes the mediation effect and the direct effect using simulated potential values that are generated from the two regression models.

The results are displayed in **Figure 5**. Each point in **Figure 5** is an estimated effect of a one-level increase in familiarity on the likelihood of endorsing government protection. Each horizontal line indicates uncertainty about the estimated effect at the traditional 0.05 level. The red dotted lines indicate a null effect.

The estimated mediation effect represented by the black square point in each plot is positive and statistically distinguishable from zero in every case ($ps < 0.000$).[2] For example, the black square point in the left-most plot indicates that a one-level increase in participants' familiarity with the dugong is predicted to increase the level of endorsing protection for the animal by about 0.1 *by making people like the dugong*. All other mechanisms not intervened by liking, which correspond to the direct effect, do not have a significant impact on the likelihood of endorsing government protection for the dugong ($p = 0.44$).

A similar pattern appears in every case as the five plots in **Figure 5** show. Although the direct effect is statistically significant at the 0.05 level in the cases of the hawksbill sea turtle ($p = 0.004$) and the saker falcon ($p = 0.02$), it contributes to the total effect far less than the mediation effect. To be specific, the mediation effect is predicted to contribute to about 0.65–0.88 of the total effect in every case.

These results support our hypothesis that the extent to which people like a threatened animal mediates the link between people's familiarity with the animal and their endorsement of government protection. We also find that these results remain constant across different cultural groups. Based on our findings, we suggest that there exists a cross-cultural mechanism through which people's familiarity with an animal at risk tends to make

[2]The values of p were computed using nonparametric bootstrap confidence intervals by the mediation package.

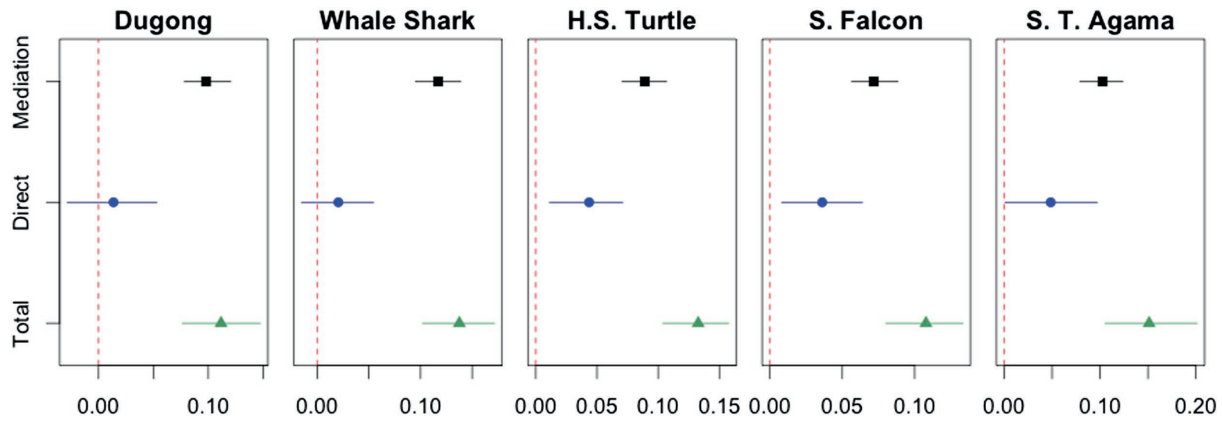

FIGURE 5 | Mediation analysis results: estimated mediation, direct, and total effects and 95% nonparametric bootstrap confidence intervals. Red dotted lines at 0 indicate a null effect.

them like the animal, and their subjective liking, in turn, increases the likelihood of their endorsing government protection for the animal.

DISCUSSION

The present study provides the first comparison of attitudes toward threatened animals and conservation across a wide range of cultural groups, including understudied populations. The goal of this research was threefold: to assess the ranking of animals across diverse cultural groups; to examine the ways in which responses to questions about familiarity, liking and endorsement for government protection toward indigenous animals in the Arabian Gulf might vary across diverse cultural groups; and to explore potential mechanisms leading people to endorse government protection for threatened animals. As the first study about this topic to address a diverse sample from a single geographic location, we shed light on how the attitudes of people toward animals compare across cultures. Our data reveal both strikingly similar shared attitudes toward animals across the diverse cultures studied and some intriguing cultural variation.

Previous findings (e.g., Martín-López et al., 2007) have demonstrated that people living closer in geographic distance to animals are more aware of and express more concern for animals near to them. In our study, all participants lived in the same small peninsular state of Qatar, and thus were similarly geographically located. A primary difference between participants in this study is in cultural backgrounds. In our analyses, WEIRD participants were compared with participants from the Arabian Gulf, Middle East and North African (MENA), Sub-Saharan Africa, South East Asia, and South Asia.

Similarities Across Cultures

One of the most important results from our study was the influential role of a person's subjective liking of animals on their opinions about the need for animal conservation. Despite the fact that the participants in our study were interested in animals and conservation (as suggested by their self-selection without incentive to participate, and overall high levels of liking for animals), their responses exhibited significant variability in attitudes toward animals. The general agreement across cultures in ranking order is striking: Across every culture, the hawksbill sea turtle was highly ranked and the spiny-tailed agama ranked consistently lowest. It is interesting that the dugong did not rank higher, as mammals are typically ranked the most charismatic species, at least amongst Westerners, although most species ranked as charismatic are terrestrial (Albert et al., 2018; Courchamp et al., 2018). Although reptiles are generally considered to be non-charismatic species (e.g., Tisdell et al., 2006), turtles have been shown to be an exception in other studies and cultures (e.g., Senko et al., 2011; Borgi and Cirulli, 2015). Other studies have found that a fear of reptiles appears across cultures (Arrindell, 2000; Ceríaco, 2012; Pandey et al., 2016; Pinheiro et al., 2016) and from a young age (e.g., Prokop and Fančovičová, 2013), suggesting a culturally universal dislike for most reptiles. The spiny-tailed agama is a fairly typical reptile, but the hawksbill sea turtle is arguably atypical: It is graceful, non-threatening, and its survival is clearly jeopardized by human activities. It would seem our results support the finding that the hawksbill sea turtle is a strikingly charismatic marine reptile that could potentially serve as a universally appealing flagship species. In Qatar, the high ranking of the hawksbill sea turtle could be also be influenced by recent efforts to raise awareness. For example, the turtles have appeared periodically in the local news and the Qatari government closes a popular beach in the summer for nesting. It is possible that these conservation activities have influenced people's perceptions and attitudes to some degree. To address these possibilities, future research is needed to understand how marketing campaigns and conservation efforts in Qatar impact attitudes, perceptions and behaviors of residents.

Additionally, as nuances in charisma between and within species have been reported in the literature, it would be incorrect to assume that all mammals are charismatic and all reptiles are not (e.g., Stokes, 2007; Prokop and Fančovičová, 2013). The dugong and whale shark appeared closely together in their rankings across all groups, perhaps because of their large size and similar appearance (Kellert, 1993; Metrick and Weitzman, 1996; Ward et al., 1998; Tisdell et al., 2006). Previous research would predict higher rankings for these animals due to their large size; however, they placed below the hawksbill sea turtle and, for some cultures in our study, also below the saker falcon. It is possible that these large marine animals evoked some degree of fear based on historical ideals of marine animals (see Mazzoldi et al., 2019 for discussion).

Previous studies have highlighted the importance of phylogenetic closeness in influencing liking and conservation of animal species (e.g., Colléony et al., 2017; Prokop et al., 2021). The hawksbill sea turtle was consistently ranked highly, and this species is more phylogenetically distant from humans than other species (e.g., the dugong is a mammal). Our findings suggest that phylogenetic closeness is not a major determinant of attitudes, or is at least one of multiple factors influencing attitudes (see Fančovičová et al., 2021 for a similar discussion). Altogether, our data demonstrate how people, irrespective of culture, readily rank animals according to their preferences and that, with some nuances, there is remarkable similarity in animal rankings across the cultural groups. Both outcomes are interesting and seem to be largely independent of culture. We will discuss the saker falcon ranking and the few group differences related to ranking in more detail below.

Our most intriguing result demonstrates how participants' willingness to endorse animals for government protection was based on their personal preferences for animals, regardless of culture. These findings are in line with previous research using WTP paradigms, which also found that participants' endorsements in the form of donations were predicted by animal liking and not by other factors such as threatened status of the animal or knowledge of animals in the general population (Colléony et al., 2017; Echeverri et al., 2017) though this may not hold true for specialists. Previously, Tisdell et al. (2005) reported likeability as the main predictor of public support for wild animals in Australia, whereas the importance of likeability, which may be related to empathy, aesthetics or other factors particular to human preferences have also been noted in previous research (DeKay and McClelland, 1996; Metrick and Weitzman, 1996; Gunnthorsdottir, 2001). Our data suggest that decision making about animal conservation worldwide, irrespective of culture, will be strongly influenced by subjective liking. This finding is important because it corroborates previous research which has demonstrated how preferences have influenced policy making (Coursey, 1994; Metrick and Weitzman, 1996; Czech et al., 1998; Knegtering et al., 2002; Mahoney, 2009).

It may be that decisions about conservation are being influenced by what Kahneman (2011) coined as System 1, rather than System 2. System 1 is described as our default decision making system, which relies on biases, heuristics and emotions to make quick and efficient decisions, whereas System 2 is slower, methodical, critical and aware. Consideration of our results in light of existing literature on decision making suggests that policy makers could benefit from understanding how their own personal biases toward conservation issues might influence their decisions and how they can leverage thoughtful and unbiased approaches to the implementation and design of related policies, including communication with the public. Further interventions could include explicitly teaching children this thoughtful approach in schools and encouraging the public to think about the consequences of treating animals unequally (i.e., the impact of imbalances in biodiversity on ecosystems).

Finally, the similarities described here across cultures (i.e., the finding that people are influenced by their subjective liking when making decisions about endorsement for government protection, as well as the similarity in animal ranking across cultures) suggest the presence of cultural universals. Cultural universals are interesting because their presence indicates that some cognitive processes operate largely outside the influence of the environment (Norenzayan and Heine, 2005). The power in identifying cultural universals is in the generalizability of psychological findings across cultures. In the case of attitudes toward animals, our data suggest that the role that liking plays in conservation efforts should be taken into consideration when designing conservation campaigns globally.

Differences Between Cultures

Our analyses revealed that overall, the different cultural groups expressed varying degrees of familiarity toward the animals. Not surprisingly, the saker falcon and the spiny-tailed agama were most familiar to participants from Arabian Gulf, MENA and Sub-Saharan African countries. Interestingly, although all animals are native to the Arabian Gulf, participants from this region were less familiar with the dugong, spiny-tailed agama and hawksbill sea turtle than the WEIRD and/or South East Asian groups. Our mediation analysis reveals that familiarity was not a strong predictor of endorsement of government protection. It would seem that familiarity is a means by which someone might come to know of an animal, and may drive liking to some degree, but is not as important as liking in driving endorsement of government protection of animals.

Although participants generally liked the animals (with the exception of the spiny-tailed agama), there were group differences in the degree of liking. WEIRD and South East Asian participants consistently indicated more positive attitudes toward animals than other groups, even when they were less familiar with the species (i.e., saker falcon and spiny-tailed agama). It is striking that Arabian Gulf participants liked all animals less than WEIRD participants, even though these animals are indigenous to their home region and in the case of the saker falcon and the spiny-tailed agama, play significant cultural roles. The attitudes held by

respondents from the Arabian Gulf were consistent with the attitudes of the overall MENA group, and to a large degree respondents from Sub-Saharan Africa as well, thus suggesting that lower levels of animal liking might be more common in these regions.

Interestingly, the saker falcon was the only animal which changed rank dramatically between cultural groups. It is not surprising that animal preferences would be influenced by culture, but it is surprising that only the saker falcon shows strong variation. A possible explanation for why it ranked higher in the Arabian Gulf, MENA, Sub-Saharan African and South Asian contexts could be that it fills a special role or ideal for those cultural groups. For example, in Qatar, the saker falcon was used traditionally for hunting and is still used by locals in recreational hunting today. On the other hand, another animal with cultural significance in Qatar and the MENA region, the spiny-tailed agama, ranked lowest; it is an animal that locals encountered frequently in the desert and was a source of food in the past. While the saker falcon still serves as an important cultural symbol, the spiny-tailed agama does not, so perhaps cultural relevance does not influence its ranking.

Conclusion

The majority of psychological research studies have been conducted with WEIRD populations; without further input from other global perspectives, psychological theory is limited. Research on cross-cultural perspectives of pressing global concerns can provide much needed guidance and advice for policy makers. Our research sheds light on global perspectives by comparing participants from WEIRD countries with previously understudied or unstudied populations from the Arabian Gulf, MENA, Sub-Saharan Africa, South Asia and South East Asia on their attitudes toward animals and conservation. All participants lived in the same geographic location, Qatar, and were tested using the same instrument within a short period of time. The animals under investigation are all indigenous to the Arabian Gulf and are all threatened species according to the IUCN red list.

Overall, participants generally indicated they liked most animals, and for the most part, ranked animals in a similar order across cultures. However, reported levels of liking were higher for WEIRD and South East Asians than for other groups. Although participants were likely to be animal enthusiasts, they all showed clear preferences for certain animals over others; for example, ranking the hawksbill sea turtle as consistently more liked and the spiny-tailed agama as less liked than the other animals. Across groups, liking emerged as the primary predictor for endorsement of government protection over and above familiarity, which independently explained very little significant variance. Future research should explore liking as a mechanism for improving attitudes toward animals and conservation decisions. Previous studies with adults have demonstrated improved liking toward animals when education has both empathy and biological literacy components (Candea, 2010; Root-Bernstein et al., 2013; de Pinho et al., 2014). Studies with school children further demonstrated the power of education on improving attitudes toward typically disliked animals (Ballouard et al., 2012; Randler et al., 2012; Collado et al., 2021). Indeed, a great deal of research points to the critical role that early education (both formally and informally) and experiences in natural settings have on shaping attitudes toward animals, and that these experiences shape future thinking (Dunlap, 1989; Soga and Gaston, 2016; Whitburn et al., 2020). Tactics suggested by this literature can be applied to improve conversation attitudes toward the spiny-tailed agama. Developing a program to raise awareness of the spiny-tailed agama through providing opportunities for Qatari residents to interact with and even handle these animals in a controlled environment may reduce negative attitudes and increase liking and conservation endorsement for these important creatures (Prokop et al., 2009; Randler et al., 2012).

In the Arabian Gulf, the local populations have the most control over conservation in the region and yet our research demonstrates attitudes toward animals and conservation amongst this group are the least favorable of the groups surveyed. Thus, it seems vital to improve animal liking in the Arabian Gulf to support conservation of these indigenous species. Qatar has well-defined goals to support biodiversity within its borders (Qatar General Secretariat for Development Planning, 2011; Qatar Ministry of Environment, 2014), and the current study suggests that increasing liking will support attainment of these goals. Because our data suggest that the role of liking in conservation is universal across cultures, it is theoretically possible to generalize from lessons learned in other cultures on improving liking and conservation to shape education efforts.

DATA AVAILABILITY STATEMENT

The datasets and R code used in this study can be found in Harvard Dataverse: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/NGWFFU.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Carnegie Mellon University in Qatar (CMU-Q) local Institutional Review Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

JB, LB, RA-H, SA-H, AA-K, and AA-N conceptualized and designed the study, and collected the data. JB and TP conducted statistical analyses. JB, LB, and TP wrote and

edited all drafts of the article and approved the submitted version. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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Integrating Observation and Network Analysis to Identify Patterns of Use in the Public Space: A Gender Perspective

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In the last few decades, increasing attention has been given to gender issues in urban design. However, research on the urban environment continues to show large gender inequalities, which are especially evident when studying the use and enjoyment of the public space. This study aims to identify predominant patterns of use in public places and to explore the possible existence of traditional gender roles in the urban space. The study uses, three public spaces in the city of Barcelona as a case study, an innovative combination of systematic observation techniques and network analysis procedures. Variables collected by EXOdES, a dedicated software analysis tool for systematic observation, are represented as nodes of a network system and analyzed using network analysis tools. Findings confirmed that, in spite of the progressive consolidation of feminist urbanism, uses in the public realm resulting from traditional gender roles remained explicitly recognizable. Whereas women's occupation of space was related to playground and resting areas, generally involving care activities concerned with children or elderly people, men were primarily located in resting and sports areas, practicing sports, or participating in leisure activities. These patterns of use were more prone to emerge when users were part of a group than when they were alone. From a gender perspective, a contribution of the study is that it informed about main aspects of the analyzed public spaces reconfirming the existence of traditional roles in society, and the significance of exploring the public space as a key scenario where social features are explicitly exposed. From a methodological perspective, the processing of observational data with network analysis tools proved to be relevant and suitable for dealing with the intricacies of urban place analysis. Compared to more classical approaches and systems, these techniques allowed to identify and interpret complex systems composed of many variables and relationships in a relatively straightforward manner, which turns it into a useful aid for urban designers and architects.

Keywords: public space, gender analysis, spatial patterns of use, systematic observation, network analysis, environmental psychology, urban design

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INTRODUCTION

Nowadays, the interest in the public space has been renewed by actualizing the ideas of Lefebvre (1968) and Jacobs (1961), among others. Beyond the modern urbanism movement, the quality of urban life is, nowadays, drawn not only in terms of urban design and functionality but considering the social quality of city life. Indeed, public places are social places, where multiple interactions occur. As public space dynamics reflect what is socially relevant in a definite context (Andretta et al., 2015), the analysis of public urban places from a socio-environmental perspective leads to identifying social phenomena that affect the vitality of public life. Among these phenomena, the gender perspective analysis is one of the most relevant issues in the current urban debate. This study aims to identify predominant patterns of use in three public places in the city of Barcelona and to explore the possible existence of traditional gender roles in the urban space.

In traditional Western societies, women were assigned primary responsibility for childcare (Hartmann, 1981) and household activities (Schooler et al., 1984). These roles have dramatically affected their experience in public space, as well as their participation in leisure activities (Mowl and Towner, 1995). Franck and Paxson (1989) referred to several effects because of these. The most prominent one is that women's mobility tends to be more restricted than that of men. The engagement in housekeeping and childcare led women to be less prone to benefit from the public space for discretionary use, often accompanied by little children or older people. In this regard, the presence of men is predominant in public spaces characterized by amenities such as betting, chess playing, or sports facilities such as baskets, football, and baseball courts. When alone, women tend to avoid public spaces perceived as unsafe, especially those with low maintenance or dirty. According to these scholars, compared with men, women are more likely to interact with others and are inclined to stay in populated spaces, particularly those inhabited by other women. Tackling these effects implies enhancing the publicness of public spaces, that is, increasing social diversity, variety of uses, and the acceptance of differences in terms of aspects such as gender, culture, ethnicity, and age. As stated by feminist urbanism, and the program for urban resilience from a gender perspective (Un-Habitat, 2018) urban design must rule over a key principle: if public spaces will be good for women, then they will also be good enough for everyone.

From the feminist urbanism perspective, the social role of high-quality urban places is crucial to promoting egalitarian use and enjoyment in the city. Urban life must reflect the diversity of existing social life, and the presence of disparate social groups -in terms of gender, race, origin, or status- because of their citizenship. In the words of Paravicini: "Urban living, particularly from the viewpoint of women, promises liberation from social control, from traditional gender roles and spatial designations" (Paravicini, 2003, p. 58). Accordingly, the urban role of high-quality public spaces can be regarded as of large importance since social, cultural, and gender-specific differences are perceived and experienced as an enhancement of urban living. However, it is fundamental to understand the extent to which these gender traditional roles are eradicated from the public realm. More research is needed to gain insight into the extent that which women are equally considered to men in what is called, following Lefevbre (1968), the right of the city. Much attention has been devoted to this issue in the feminist urbanism debate nowadays (Beebeejaun, 2017; see also www.right2city.org).

In spite of the increasing endorsement of the gender perspective in urban thinking and urban design (Little et al., 1988; McDowell, 1993; Bondi and Rose, 2003; Sánchez de Madariaga and Roberts, 2016), feminist urbanism studies show that with respect to urban settings, women's needs and requirements are not considered as much as men. Recent research on urban analysis has shown large gender inequalities that involve mobility systems (Hanson, 2010; Pirra et al., 2021), urban facilities, and urban structure (Spain, 2014). To some extent, this situation occurs because cities are designed and managed mainly by men (Beebeejaun, 2017). Another reason is that urban space production is the outcome of social patriarchal structures, which impose barriers to women—both functional and symbolic—for the use and enjoyment of the urban public space (Blackstone, 2003; Bondi and Rose, 2003; Neaga, 2014).

Based on many key studies (Jacobs, 1961; Barker, 1968; Gehl, 1987, 2010; Barker, 2016; Sennett, 2017; Delclòs-Alió et al., 2019), public places can be conceptualized as complex systems. As such, they are made up of many variables (related to urban design, topological features, weather conditions, social interactions, individual dispositions, etc.) relating to each other in intricate configurations. It was Jane Jacobs who was among the first to view the public space as a place of complex and changing order. In the public space, people and groups—like dancers of a ballet—perform together in apparent chaos creating order within a hidden system. She referred to this aspect as "The art of the street" (Jacobs, 1961). This poetic, yet rigorous, account of street life offers a landmark example of what can be regarded as an ecological or systemic approach to space. This idea supposes considering human behavior as an outcome of socio-environmental system requirements. The assumption is that human behavior is a function of socio-environmental system demands. Among the many disciplines that have endorsed this approach are urban ecology and sociology. Consequently, in the words of Redman et al. (2004), an environment can be described as "a coherent system of (. . .) physical and social factors that regularly interact in a resilient, sustained manner, that is, a perpetually dynamic, complex system with continuous adaptation." While understanding the public space as a complex network is a powerful concept, studies in environmental psychology literature that adopted methodological approaches from a systemic perspective are scarce. One of these is Roger Barker's Behavior Setting Theory, which aims to investigate human behavior in daily contexts. According to Baker (2016), in a behavior setting, individuals, actions, and objects follow recognizable patterns. This theory sought to explain, perhaps for the first time scientifically, small-scale socio-environmental systems, as well as to study behavior in natural settings. However, as Popov and Chompalov (2012) highlighted, the behavior setting concept had very little impact on mainstream psychological theories (Wicker, 2002). In spite

of this, Barker pioneered the ecological approach to psycho-environmental analysis, representing one of the most important perspectives in the discipline (Winkel et al., 2009).

Although the Behavior Setting Theory aimed at identifying environmental patterns of use, few studies have analyzed patterns involving social use of public places. Cao and Kang (2019) defined a pattern of use as "the ways that people use a space, which usually comprises activity and spatial occupancy" (op. cit., p. 189). The relationship between functionality and urban design was explored by Alexander (1977, 1979), who defined a pattern language as a way to analyze prototypical ill-structured urban design problems. He suggested a comprehensive list of standardized solutions to recurring urban uses and design situations that have influenced the way urban spaces are analyzed and designed today (Casakin, 2018). Gehl (1987) investigated environmental patterns and identified three types of human activities in urban places, including the necessary, optional, and social activities. For him, a public place ought to offer possibilities to develop all types of activities at different moments of the day, and for various users. This researcher proposed a set of valuable tools and a list of recommendations to observe urban social phenomena (Gehl and Svarre, 2013). Considering the process of privatization of public spaces and their progressive control surveillance, Cybriwsky (1999) studied the changing patterns of use of urban centers such as Battery Park City in New York and Yebisu Garden Place in Tokyo. These processes were found to restrict the social use of the space and reduce the quality of urban life. Golièn̈ik and Thompson (2010) analyzed patterns of use in parks based on GIS and behavioral mapping. Cao and Kang (2019) studied four public places in the United Kingdom and China and using Hall's (1966) social distance typology, they identified patterns of use that differ depending on if people were alone or in a group. In particular, women were more likely to stay in the group. Single users, on the other hand, were prone to be in the periphery, while groups were spatially distributed. Based on this literature, the current study depicts a pattern of use in the urban public space as a set of three interacting variables dealing with a user's profile, a specific physical environment or space, and certain use of the space (Casakin and Valera, 2020; Valera, 2020).

What is common to the studies that analyze patterns of use is the systematic observation as a methodological approach (Cybriwsky, 1999; Golièn̈ik and Thompson, 2010; Koen and Durrheim, 2010; Gehl and Svarre, 2013; Metha, 2014; Cao and Kang, 2019; Park, 2020)? Such an approach showed to be effective in the analysis of natural contexts (Anguera, 2003; Anguera et al., 2019) it is widely used in many recent studies. Differentiating itself from other empirical approaches such as self-report, systematic observation is a direct method that offers the possibility of collecting objective information with strong internal validity, while it allows the concurrent generation of data about the physical and social environment where an activity occurs (McKenzie and van der Mars, 2015, Park, 2020). This is, for instance, the methodology adopted by Iqbal and Ceccato (2016) to study the safety of urban parks in Stockholm considering CPTED criteria, and by O Caughy et al. (2001) to assess the impact of parks in urban neighborhoods' on the well-being of families and children.

Finally, in previous studies, we dealt with the issue of gender analysis in public places by using an observational methodology (Pérez-Tejera et al., 2011, 2018). By analyzing a wide sample of public places, results offered much evidence on gender uses of the space (i.e., gender occupancy, preeminent activities, race profile, etc.). However, it was difficult to identify with precision, specific patterns of use that clearly related to gender roles. This issue is mainly because of the use of Polar Coordinates Analysis for exploring the collected data. This is a reduction data technique based on multievent sequential analysis (Bakeman and Quera, 2011) for exploring relationships between a focal behavior and one or more conditional behaviors (Gorospe and Anguera, 2000). Significant relationships are depicted in several vector maps indicating the extent to which the conditional behaviors are excitatory or inhibitory of the focal behavior. Despite its strengths, the Polar Coordinates Analysis technique presents some limitations, mainly concerned with the need to generate as many vector maps as the number of values of the observed category (known as focal behaviors), and the rest of the observed categories (known as conditional behaviors). Consequently, numerous separate analyses must be carried out, each one revealing only a partial aspect of the pattern of use. Hence, to arrive at more comprehensive conclusions, hard post-integration analysis of the partial results is required. To deal with this problem, it is necessary to explore techniques that allow an integrative analysis of a large amount of observational data straightforwardly.

Bearing this research gap in mind, the goal of this study is to detect predominant patterns of use in public places, as well as to analyze the extent to which the existence of traditional gender roles can be still detected. For this purpose, the current study relies on the innovative combination of systematic observation techniques and network analysis procedures (Casakin and Valera, 2020; Valera, 2020). To achieve these goals, it will be necessary to establish: (1) what are the main user's profiles in public places, (2) what type of activities they are involved in, and (3) where they are located.

MATERIALS AND METHODS

Case Studies

The main reason why works dealing with the observation of urban spaces opt for the case study methodology (Cybriwsky, 1999; Metha, 2014; Cao and Kang, 2019; Park, 2020) is because it allows a focused evaluation of the object of study based on selected space attributes. In our study, three urban public places in the city of Barcelona were selected and analyzed with the aim of identifying patterns of use that disclose gender differences. In the last decades, Barcelona has become an example of urban design quality, characterized by a process of urban regeneration referred to as the "Barcelona Model" (Monclús, 2003; Doğan, 2021). While this model succeeded in the urban design realm, it was criticized for failing to produce significant social changes such as a more democratic use of the public space (Blakeley, 2005; Degen and García, 2012). This was particularly relevant for the public spaces located in low-middle class areas, such as the sites

selected in the present study. While they can be categorized into different typologies of urban spaces (Carmona, 2010), the sites share several features that justify their inclusion in our study. Firstly, all three are public places created in the same historical period of the urban development of Barcelona. It was between the years 1980 and 2000, during the Barcelona Model period, when city planners acted in two major directions: conducting a large-scale urban renewal around the 1992 Olympic Games area (1992) and enforcing an urban design policy for new high-quality urban spaces, especially in areas previously neglected. Secondly, the selected case studies are located in traditional districts of the city such as Raval, Poble Sec, and Clot, characterized by historical deficiencies in urban facilities. And by a middle-low or low-class population. Finally, these places replaced totally or partially ancient factories, but at the same time, they conserve singular elements (e.g., chimneys, entrances, parts of walls, and big pieces of the original machinery) reminding the industrial past of an era. Consequently, we assume that the cases selected are appropriate for this study. These are described as follows:

St. Pau del Camp Gardens (**Figure 1**) is a 9,600 sq. m area created in 1992 in the Raval district to replace decaying buildings and an old factory, whose chimney remains in place. A large green area forms a small artificial hill to overcome the unevenness of the terrain caused by an underground parking lot. A series of gardens surround the Romanesque monastery of St. Paul in the Fields. Between the parterres (i.e., ornamental arrangement of flower beds), excavated semicircular paths extend along the medium-height walls designed to relax and enjoy. A sports court and a little playground complete the landscape.

The Three Chimneys Park is in the Poble Sec district. Created in 1995, its name is an allegory to three big chimneys conserved from the original power station in Barcelona, popularly known as "The Canadian." At the beginning of the 20th century, the company was a national pioneer in the production of electrical power. With an area of 8,890 sq.m, the park is structured into two main zones: one is a large central esplanade partly surrounded by a building and a low wall; it contains sitting places and a large concrete cube designed as a stage for celebrations. The other is a pavement area with geometrically organized tree plantations and a playground court containing ping pong tables (**Figure 2**).

Like the other sites, Pegaso Park is a green area formerly occupied by an emblematic truck factory, located between the

FIGURE 1 | St. Pau del Camp Gardens, **(a)** Passage zone with the chimney of the old factory; **(b)** Playground area located in the lowest level of the park; **(c)** Resting area, located near the sport court; and **(d)** Artificial hills surrounding the Romanesque monastery of St. Paul in the Fields. Source: Authors.

FIGURE 2 | Three Chimneys Park, **(a)** The esplanade; **(b)** Passage area characterized by trees and parts of the old machinery used as sculptures; **(c)** Playground area, ping-pong tables, and resting zone with benches; and **(d)** Panoramic view of the iconic three chimneys that give the park its name. Source: Authors.

old historic districts of Sant Andreu and La Sagrera (**Figure 3**). Inaugurated in 1986, its name comes from the popular Pegaso trucks produced in this factory. With an area of 36,500 square meters, Pegaso Park is the largest of the three. The main entrance preserves part of the façade of the factory. The Park has organized into two main sectors: a shaded esplanade, bordered by Privet trees, a lake, and low hills. At the top of the park is a promenade surrounding a sports center and play areas for children connected to a lake. A water channel flowing from the lake is the major landscape element. It crosses the park diagonally running through exuberant and shady vegetation reminiscent of Riparian forests. Bridges as original as those inspired by the traditional Japanese architecture cross the canal at key points along its route.

Observational Procedure

In this study, we used an N/F/M observational design (Anguera et al., 2001). N is for nomothetic (making observations of dissimilar places and groups of people), F is for intersessional follow-up (recording of several sessions), and M is for multidimensional (analysis of the multiple macro-criteria involved in the observational device).

With the help of the City Council of Barcelona, an observation tool (EXOdES) was created to explore how parks are used, and what are the main environmental features and activities that occur in space. The EXOdES instrument allows the recording of simultaneous behaviors involving multiple criteria through the combined use of category systems and field formats. In particular, it enables the classification of the data based on 26 dimensions organized under four macro-criteria: (i) context, (ii) groups and individuals' profiles, (iii) activities, and (iv) environment. Information about the setting was coded according to its function (i.e., passage zone, resting zone, playground, green area, etc.). The observed individuals were coded according to gender (i.e., male, female), group age composition (i.e., child, teen, adult, elder), and ethnicity (i.e., White, Latin, Arab, Asian, and African). Groups of people were coded considering their size (i.e., 2, 3–5, 6–10, and 10–20), gender (i.e., men, women, mostly men, mostly women, and equally mixed), age composition (i.e., children, teens, adults, elders, children with teens, adults with elders, and children or teens with adults or elders), and ethnicity. Both individuals and groups were also coded regarding the presence or absence of signs of homelessness. Public space use was coded according to three indicators: main activity (i.e., talking or resting in place,

FIGURE 3 | Pegaso Park, **(a)** Main entrance of the park, preserving the original access to the factory; **(b)** The lake surrounding the playground area in the esplanade; **(c)** Bridges, paths, and canal flowing to the lake; and **(d)** Paved playing area serving as a transition between the main entrance and the green areas. Source: Authors.

picnicking, sleeping, playing, walking, practicing sports, and mental activities such as reading a book or playing cards), use of transport vehicles (i.e., motorized vehicles, bicycles, strollers, wheelchairs, and skates or roller skates), as well as the presence or absence of social incivilities (i.e., drunkenness, drug consumption or drug dealing, prostitution, urinating in public, and illegal street vending). Finally, the environmental assessment included aspects such as level of cleanliness, graffiti presence, level of maintenance of green areas, and visual control (Pérez-Tejera et al., 2011, 2018; Valera et al., 2018). Depending on the type of variables, systems of categories were created for criteria with a limited range of options (e.g., age, gender, and racial or ethnic group), and catalogs (field formats) were generated for criteria with unbounded options (i.e., type of transportation vehicles and type of activities) that could be expanded upon observing new responses. This up-to-date version of EXOdES included 280 mutually exclusive variables (codes).

Observations were carried out by six observers. The training was conducted by the researchers for a period of 4 weeks. It included practicing the coding process by using photographs and field-based observations until assuring high levels of inter-rater reliability. The quality of the data was controlled by the kappa Cohen's coefficient, which exceeded 80%. To guarantee representativity of the use of spaces, all study sites were visited eight times per day (i.e., the observation period) during the following slots: 10:00–11:00, 11:00–12:00, 12:00–13:00, 13:00–14:00, 16:00–17:00, 17:00–18:00, 18:00–19:00, and 19:00–20:00. To reduce potential bias, at the end of the study each site was observed by at least three observers on three different weekdays. In a typical observation session, observers scanned the site and recorded all detected events. A scan is a visual sweep from left to right across the target area. Each record of EXOdES was represented synchronously as a set of variables (or dimension values) characterizing an event that occurs in a certain place. An EXOdES record included information about the observer, the place being observed, the date and the observational period, the demographic characteristics of an individual or group using the site, the activity being performed, and the environmental characteristics of where the activity takes place. In each location, events were observed for 45-min. They were recorded by means of an application for electronic devices (**Figure 4**) that allows using of EXOdES in an easy and discreet manner, avoiding a contamination effect from the observers. EXOdES application is available at www.exodes.org.

The final database comprised 3.122 records: 782 in St. Pau del Camp Gardens, 1.100 in Pegaso Park, and 1.240 in Three Chimneys Park. These records were collected during 108 sessions

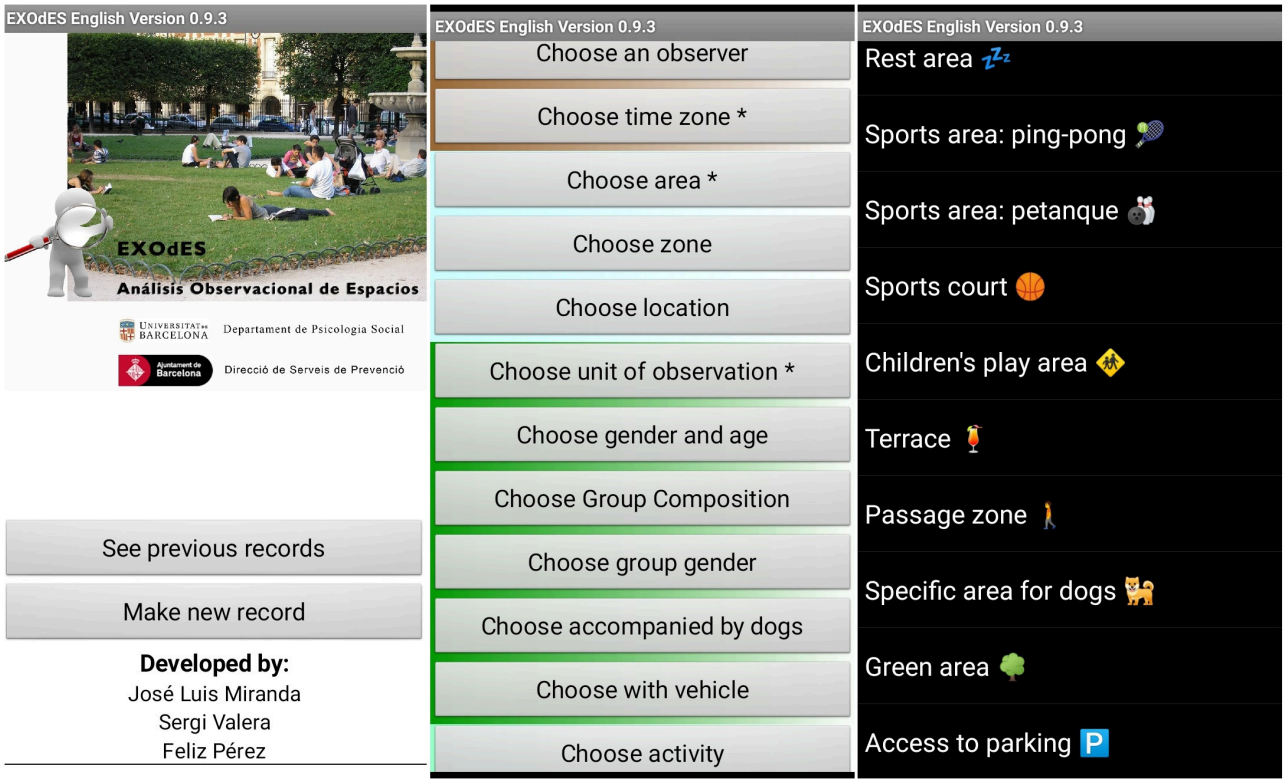

FIGURE 4 | Screenshots illustrating the EXOdES tool.

along different time slots (36 sessions per case study) representing 27 h per site, which is 81 h in total (see **Table 1**).

Network Analysis

After collection, data were analyzed as a network system. Based on Graph Theory, studies on Network Analysis argued that a large part of the systems found in nature, even in society, can be described in terms of networks, which allows capturing the intricate web of connections between the units of which these networks are made (Wasserman and Faust, 1994; Cartwright and Harary, 1956; Palla et al., 2005; de Nooy et al., 2018). In our study, each record of EXOdES is considered a set of variables that are represented as nodes in a network and are related to each other in terms of co-occurrence. This principle is repeated throughout all observed events. As a result, a system of relationships between nodes is configured, generating non-directional networks that reveal how specific public space functions and behaves. To this aim, network analysis freeware software was employed. The collected observational information was analyzed using Pajek (de Nooy et al., 2018). This software represents data as networks through a combination of vertices and lines according to definite criteria. In our case, vertices (or nodes) were variables related to the selected observational categories, and lines were defined as co-occurrence relationships identified between these variables. Furthermore, Pajek provided indexes of both the network itself (centralization indexes) and the nodes involved (centrality indexes). Additionally, visualizations, clustering, and centrality indices provide critical information for understanding the dynamics of the network. Particularly, visualizations and clustering – i.e., grouping nodes by specific criteria – allow the representation of key components of the network. Once created, networks were exported from Pajek to VosViewer software (Van Eck and Waltman, 2011) via an available function of this application. This software was used for network visualization and clustering analysis. Options in normalization methods and clustering resolution allowed for obtaining optimal layouts for visualizing results.

TABLE 1 | Distribution of the hours of observation per case study.

	Case studies				
Observational period	**ST.PAU DEL CAMP GARDENS**	**THREE CHIMNEYS PARK**	**PEGASO PARK**	***n***	***M***
10:00 to 11:00	3	3	3	9	3
11:00 to 12:00	3,75	3	3,75	10,5	3,5
12:00 to 13:00	2,25	3,75	3	9	3
13:00 to 14:00	3	2,25	3,75	9	3
16:00 to 17:00	3	4,5	3,75	11,25	3,75
17:00 to 18:00	3,75	3	3	9,75	3,25
18:00 to 19:00	3,75	3,75	3,75	11,25	3,75
19:00 to 20:00	4,5	3,75	3	11,25	3,75
	27	27	27	81	

This work was conducted in accordance with the Declaration of Helsinki. The study was exempt from ethics committee review and written informed consent, since: (a) it concerned the observation of people in public places where there was no expectation of privacy for those being observed; (b) The observer did not implement interventions or interactions with individuals or groups; and (c) No personal information captured by using photographs, films, or videos footage was shown in the research findings.

RESULTS

According to the definition of patterns of use adopted in the present study, several categories were selected for these results considering the proposed macro-criteria that included: (i) functional areas; (ii) gender profile of persons and groups; (iii) profile of groups (number of persons and age); (iv) activities; and (v) complimentary items such as dogs and vehicles. Categories of the environmental macro-criteria were excluded in the analysis due to their impossibility to discriminating between the potential patterns of use. In this regard, after testing them in preliminary network analyses, the regularity of variables related to these categories collected from different observation sessions did not allow to relate definite environmental features to identifiable patterns of use.

Finally, data were processed to obtain three networks, that is one per case study. **Table 2** presents the main parameters and corresponding values for each of these networks. Three Chimneys Park is the biggest network, both in number of Vertices (nodes) and Lines (links between nodes). It also has the highest average Degree (average of connected nodes). However, St Pau del Camp has the highest Degree of Centralization, that is, the most compacted network. The density between networks is similar in all cases.

While centralization indexes refer to the network as a whole, centrality indexes describe nodes that are involved in a specific network. Among these, Degree (*d*) and Weighted Degree (*Wd*) are crucial. The former refers to the number of nodes that are directly connected to a definite one. Its centrality derives from how many nodes appear together with it. Nevertheless, one node can be connected to another several times. The Weighted Degree index informs the number of connections (lines) received by a node: Its centrality derives from the number of times that this node appears in the observation sessions. **Table 3** shows the main 40 nodes of each site's network ordered by the Weighted Degree index and their respective Degree indexes.

TABLE 2 | Descriptive parameters of the networks obtained in each case study.

	ST. PAU DEL CAMP GARDENS	THREE CHIMNEYS PARK	PEGASO PARK
Number of vertices (*n*)	71	85	81
Total number of lines	481	726	634
Density	0.19356137	0.20336134	0.19567901
Average degree	13.54929577	17.08235294	15.65432099
Network degree centralization	0.57991718	0.53542742	0.49145570

The main activity carried out in the observed places is *Resting* (when people are alone) or *Resting/Talking* (in the case of groups). In fact, this activity represents one of the most relevant nodes in the network. In all three case studies, it is the first ranked activity with respect to Weighted Degree, and the most important one regarding Degree measures. Together with *Passage areas* related to *Walking* activity, resting areas (*Resting_area*) are the largest visited places, except in Three Chimneys Park where *Esplanade* is also relevant. Furthermore, in general, people appear in the public space in groups rather than individually. The presence of males, especially groups of men (*Group_men*), is dominant in the places studied. In contrast, the presence of women is less frequent, and when it happens, they appear in group (*Group_women*). This effect is more relevant in St. Pau del Camp Gardens (Wd_{Group_men} = 682; d_{Group_men} = 53; Wd_{Man} = 470; d_{Man} = 20 in front of Wd_{Group_women} = 223; d_{Group_women} = 28; Wd_{Woman} = 157; d_{Woman} = 18) and Three Chimneys Park (Wd_{Group_men} = 1307; d_{Group_men} = 61; Wd_{Man} = 540; d_{Man} = 31 in front of Wd_{Group_women} = 368; d_{Group_women} = 40; Wd_{Woman} = 165; d_{Woman} = 21) than in Pegaso Park (Wd_{Group_men} = 657; d_{Group_men} = 53; Wd_{Man} = 486; d_{Man} = 26 in front of Wd_{Group_women} = 493; d_{Group_women} = 43; Wd_{Woman} = 317; d_{Woman} = 18). The presence of dogs is prominent in St. Pau del Camp Gardens and Pegaso Park, while the skaters (*Skater)* and *Skating* activity are preeminent in the Three Chimneys Park.

As noted, a pair of nodes can be interconnected with each other several times. Depending on the number of connections, the value of the line (i.e., link) between two nodes can vary accordingly. The value of the lines that link gender profile options with both, functional areas and activities was calculated. Since these values are absolute, to normalize them in relation to the network we elaborated an index representing the percentage of the number of connections that link two nodes (value of the line) of the total number of connections of the network. The resulting indexes allowed comparison among the three case studies. **Table 4** shows the index value between gender profile and functional areas, and **Table 5** depicts the index value between gender profile and use of the space in each case study.

Analyzed by case studies, St. Pau del Camp Gardens' functional areas are linked with different gender profiles. *Playground_area* relates to groups of women (*Group_women*), while resting (*Resting_area*) and leisure areas (*Esplanade, Sport_court, Petanque_court, Blue_space, and Green_area*) are connected to *Man* or groups of men (*Group_men*) (**Table 4**). *Playing* activities relate to groups of women (*Group_women*), whereas resting and talking activities (*Resting/Talking*) are linked to male users (*Man, Group_men*) (**Table 5**).

Similar results are observed in Three Chimneys Park. The playground area is linked to groups of women (*Group_women*), leisure areas (*Esplanade, Sport_court, Petanque_court,* and *Blue_space*) to groups of men (*Group_men*). Both *Resting_area* and *Passage_area* are largely related to male users (*Man, Group_men*) (**Table 4**). While there is no difference between men and women in *Playing* and *Walking* activities, the male

TABLE 3 | Weighted Degree (*Wd*) and Degree (*d*) of the 40 main nodes per case study network.

ST PAU DEL CAMP GARDENS			THREE CHIMNEYS PARK			PEGASO PARK		
Label	***Wd***	***d***	**Label**	***Wd***	***d***	**Label**	***Wd***	***d***
Resting/Talking	1,337	48	*Resting/Talking*	1,854	59	*Resting/Talking*	1,071	50
Resting_area	1,068	43	*Resting_area*	1,480	59	*Walking*	920	36
Group_men	682	53	*Group_men*	1,307	61	*Passage_area*	911	48
Man	470	20	*Esplanade*	682	47	*Resting_area*	874	49
2_adults	423	26	*Passage_area*	546	49	*Dog*	848	32
Passage_area	387	32	*Man*	540	31	*Group_men*	657	53
Dog	385	27	*Skate*	506	31	*Playing*	512	39
Group_mixt_gender	358	36	*Sport_skate*	465	30	*Group_women*	493	43
Walking	308	30	*3to5_young*	420	27	*Playground*	490	30
3to5_adults	243	23	*2_young*	407	33	*Man*	486	26
Group_women	223	28	*Group_mixt_gender*	399	42	*Group_mixt_gender*	469	54
Playground	197	28	*Group_women*	368	40	*Woman*	317	18
Green_area	190	32	*Playground*	363	33	*2_child_adult*	315	19
Playing	187	64	*2_adults*	327	26	*Esplanade*	308	41
Woman	157	18	*Playing*	283	35	*Stroller*	278	26
2_young	144	15	*Walking*	226	28	*2_adults*	271	23
2/more_dogs	139	29	*Old_man*	223	16	*Old_man*	229	13
Sleeping	105	18	*Boy*	218	22	*3to5_child_adults*	161	18
2_child_adult	101	11	*2_child_adult*	188	20	*2/more_dogs*	161	33
Esplanade	95	22	*Dog*	181	26	*2_old*	123	15
Boy	83	18	*Stroller*	177	22	*3to5_adults*	113	20
Old_man	77	11	*Bike*	175	27	*Bike*	101	31
3to5_child_adults	75	12	*Woman*	165	21	*2_child*	99	12
3to5_young	73	14	*3to5_child_adults*	144	20	*Boy*	93	15
Eating	69	17	*Sculpture*	116	26	*Work_maintenance*	93	12
Dogs_area	63	15	*Sport_biking*	100	15	*Blue_space*	91	23
Stroller	61	20	*3to5_child*	96	18	*2_young*	89	16
Sculpture	58	11	*3to5_adults*	96	14	*Petanque_court*	82	22
Work_maintenance	52	12	*Sleeping*	83	13	*Reading*	81	14
Bike	50	15	*2_old*	82	12	*3to5_young*	71	15
Automobile	42	15	*Reading*	82	15	*Old_woman*	60	9
Girl	34	6	*Automobile*	78	18	*Green_area*	56	17
5to10_adults	34	8	*Parking_area*	76	20	*Girl*	55	10
5to10_young	33	13	*Scooter*	75	22	*Stairs*	52	18
Stairs	31	10	*Work_maintenance*	70	18	*Eating*	50	17
Surveillance	31	10	*2_child*	66	17	*5to10_child_adult*	48	8
2_child	24	9	*Eating*	63	18	*3to5_child*	47	16
Child_male	22	14	*Sport_football*	62	15	*3to5_old*	41	14

Pink color represent activities; green color represents functional areas; blue color represents gender profiles; yellow color represents groups profiles; and gray color represents complementary items such as dogs and vehicles.

gender is clearly linked to resting, talking (*Resting/Talking*), and sports activities (mainly *Sport_skate, Sport_biking,* and *Sport_football*) (**Table 5**).

As regards Pegaso Park, like, in the other sites, *Playground_area* is related to groups of women (*Group_women*), as well as resting (*Resting_area*) and leisure areas (*Esplanade, Sport_court, Petanque_court, Blue_space,* and *Green_area*) either composed of solitary men (*Man*) or groups of men (*Group_men*). Conversely, passage zones (*Passage_area*) are mainly connected to singles (mainly *Man* but also *Woman*) (**Table 4**). In addition, activities such as resting or talking (*Resting/Talking*) are predominant for male users (*Man, Group_men*), although no differences exist in *Playing* activities regarding gender (**Table 5**).

When the analysis of the main components of the networks is carried out integrally, it is possible to identify patterns of use of the sites based on the visualizations of the resulting networks. For a better visualization of the results, networks generated by Pajek were exported to VOSViewer. The network visualizations generated by VOSViewer allowed clearly capturing the global structure of the nodes and their relationships. In our case, the size of the nodes is represented according to the Weighted Degree index. Hence, the bigger the node, the larger

TABLE 4 | Gender index by functional areas.

Case study(total network lines)				
ST.PAU DEL CAMP (481)	***Playground***	***Resting _area***	***Passage_area***	**Leisure area (1)**
Man	0,416	25,571	9,355	6,029
Woman	0,208	2,910	5,405	1,663
Child_male	0,416	0,415	0,623	0,415
Child_female	–	–	0,623	0,207
Boy	0,208	3,950	1,039	1,455
Girl	–	0,831	1,663	–
Old_man	–	4,158	1,663	0,415
Old_woman	–	–	–	–
Group_men	2,079	27,442	4,158	6,237
Group_women	7,692	3,950	1,247	1,663
Group_mixt	2,287	13,097	2,702	3,534
THREE CHIMNEYS PARK (726)	***Playground***	***Resting _area***	***Passage_area***	**Leisure area (2)**
Man	0,551	20,385	5,509	4,545
Woman	0,964	3,168	2,066	2,617
Child_male	0,275	0,413	0,275	0,964
Child_female	0,413	–	-	0,137
Boy	0,137	5,785	1,101	3,581
Girl	0,137	1,790	0,550	0,551
Old_man	–	11,157	2,066	0,551
Old_woman	–	0,964	0,137	–
Group_men	4,958	19,559	8,126	18,732
Group_women	6,887	6,611	1,515	1,377
Group_mixt	1,928	9,228	2,892	1,790
PEGASO PARK (634)	***Playground***	***Resting _area***	***Passage_area***	**Leisure area (3)**
Man	–	10,725	13,880	5,362
Woman	0,315	5,520	8,517	3,627
Child_male	–	0,157	–	0,315
Child_female	–	–	0,157	-
Boy	0,315	1,892	2,366	0,788
Girl	–	1,261	1,577	0,315
Old_man	–	7,097	5,836	1,419
Old_woman	0,157	1,262	1,412	0,630
Group_men	7,255	8,832	5,047	8,517
Group_women	10,094	5,520	5,520	2,208
Group_mixt	5,205	7,571	4,889	4,258

Average of lines linking areas with gender profile per case study.
(1) Esplanade, Sport_court, Petanque_court, Blue_space, and Green_area.
(2) Esplanade, Sport_court, Petanque_court, and Blue_space.
(3) Esplanade, Sport_court, Petanque_court, Blue_space, and Green_area.

the Weighted degree, and the larger the presence of this node on the network. The larger the central location of the node, the larger its relevance. Moreover, the closer one node is to another, the larger their interconnection in terms of co-presence. The size of the links between nodes are represented according to the value of the line (i.e., number of connections between pairs of nodes). Therefore, the thicker the line the higher the value of the line. Additionally, VOSViewer allows the application of cluster algorithms to the network, highlighting sets of nodes that repeatedly appear together. Depending on what information the sets or clusters contain, nodes related to users' profile, activities, and functional areas, they can be related to specific as patterns of use.

From a gender perspective, three main clusters define St. Pau del Camp Gardens' network (**Figure 5**). The green cluster is defined by single persons of both genders (*Man*, *Woman*), accompanied by dogs (*Dog*, *2/more_dogs*), preferentially walking (*Walking*) in passage zones (*Passage_area*) or green areas (*Green_area*). The red cluster is related to groups of men (*Group_men*). This node is linked with

TABLE 5 | Gender index by activity.

Case study (total network lines)					
ST.PAU (481)	***Resting***	***Walking***	***Playing***	**Sport (1)**	**Working (4)**
Man	26,819	7,900	–	–	0,831
Woman	7,277	3,950	–	–	0,208
Child_male	0,624	0,415	0,415	–	–
Child_female	0,208	0,623	–	–	–
Boy	4,366	1,455	0,208	–	–
Girl	0,416	1,663	–	–	–
Old_man	5,198	1,455	–	–	–
Old_woman	–	–	–	–	–
	Talking				
Group_men	34,927	1,039	2,079	0,831	2,702
Group_women	6,237	1,039	7,068	0,208	0,208
Group_mixt	14,761	1,871	2,494	–	1,455
THREE CHIMNEYS (726)	***Resting***	***Walking***	***Playing***	**Sport (2)**	**Working (4)**
Man	21,212	2,203	–	2,203	0,826
Woman	4,821	2,066	0,275	0,275	1,652
Child_male	0,275	–	0,275	1,239	–
Child_female	–	–	0,413	0,137	–
Boy	7,300	0,137	0,137	4,132	–
Girl	1,652	0,275	–	0,688	–
Old_man	10,606	1,652	–	0,137	–
Old_woman	0,964	0,137	–	–	–
	Talking				
Group_men	27,410	1,239	4,958	19,696	0,551
Group_women	10,055	0,413	4,958	0,826	–
Group_mixt	11,570	1,652	1,652	0,964	0,275
PEGASO (634)	***Resting***	***Walking***	***Playing***	**Sport (3)**	**Working (4)**
Man	10,725	12,618	0,315	1,261	1,419
Woman	7,413	9,621	0,157	–	0,157
Child_male	0,157	–	–	0,157	–
Child_female	–	–	–	–	–
Boy	1,892	2,523	0,157	0,631	–
Girl	0,631	2,050	–	0,157	–
Old_man	5,993	6,151	–	–	–
Old_woman	1,735	1,735	–	–	–
	Talking				
Group_men	12,776	3,470	8,832	3,154	2,523
Group_women	7,097	5,047	9,306	0,946	0,315
Group_mixt	10,094	4,574	5,362	0,946	1,104

Average of lines linking activities with gender profile per case study.
(1) Sport_football, Sport_basket, and Sport_biking.
(2) Sport_football, Sport_basket, Sport_skate, Sport_petanque, Running, Stretching, Sport_biking, and Sport_cricket.
(3) Sport_football, Sport_basket, Sport_petanque, Running, Stretching, Sport_bike, Sport_taichi, and Sport_kickboxing.
(4) Work_maintenance, and Surveillance.

the main nodes regarding Weighted Degree: talking and resting activities (*Resting/Talking*), and resting areas (*Resting_area*). Finally, the blue cluster outlines groups of women (*Group_women*) with children (*2_child, 3to5_child/adult*) and older people (*2_child_old*) (with presence of *Wheelchair*), involved in *Playing* activities are located in the *Playground* area. Interestingly, this cluster is well separated from the others, suggesting that the pattern of use is highly specific for this site.

In Three Chimneys' Park, three major clusters and a second one are observed in the network (**Figure 6**). The former ones are clearly separate in the network layout, and from each of these patterns of use related to gender can be identified. The red cluster depicts two of the higher Weighted Degree nodes

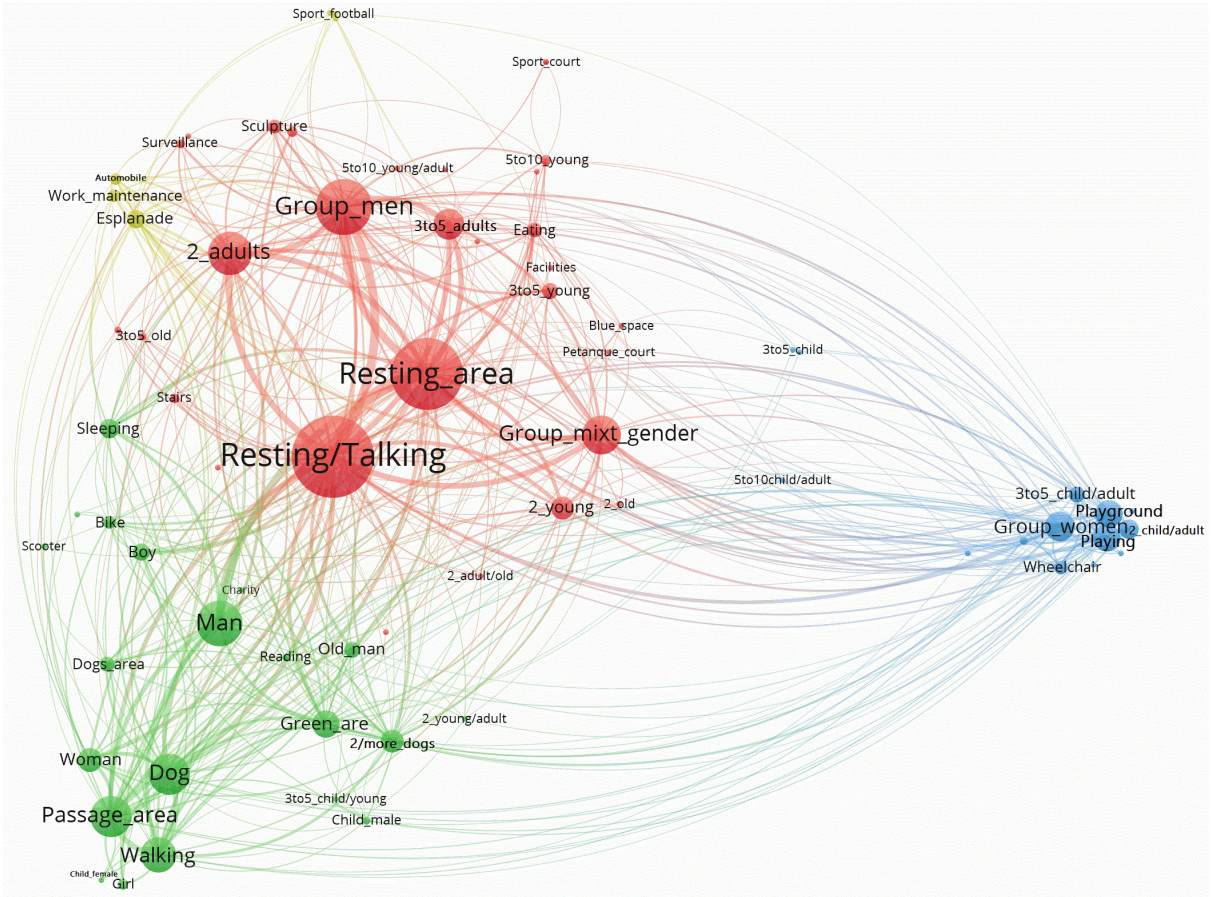

FIGURE 5 | St. Pau del Camp Garden's network by VOSviewer.

dealing with the *Resting_area* and the resting or talking activity (*Resting/Talking*) (see **Table 3**). Users in this cluster are mostly males (*Man*, *Old_man*, and *Boy*), in addition to mixed groups of gender (*Group_mixt*). *Sleeping* and *Reading* are the dominant activities appropriate for places like the *Resting_area*. The green cluster is characterized by groups of men (*Group_men*): young people (*2_young, 3to5_young, 5to10_young*) or children (*5to10_child, 10_child*) practicing skating (*Sport_skate*) in an *Esplanade*. The yellow cluster is mainly defined by groups of women (*Group_women*) with children (*Child_female, 3to5_child, 2_child/adult, 3to5_child/adult,* and *5to10_child/adult*), who are primarily located in *Playground_areas*, use *Strollers*, and are involved in *Playing* activities. The blue cluster is closely located to the red one. It is defined by the concurrence of single *Woman*, *Walking* alone, in *Passage_areas*. Remarkably, the red and blue clusters reflect the presence of single persons, while the green and yellow clusters represent groups of users.

Moreover, three well-defined clusters represent Pegaso Park's network (**Figure 7**). The green cluster is related to single persons (*Man*, *Woman*, and *Old_man*), accompanied by a *Dog*, *Walking* in *Passage_areas* or in the *Esplanade*. These nodes have a large weight in the entire network (see **Table 3**). The red cluster includes nodes with a similar weight: groups of men (*Group_men*) talking or staying (*Resting/Talking*) in *Resting_areas*. In the extreme of the network, there are elder men (*5to10_old*) practicing petanque sport (*Sport_petanque*) in the *Petanque_court*. As in previous cases, the blue cluster is defined by groups of women (*Group_women*) with children (*2_child/adult, 3to5_child/adult, 5to10_child/adult, 2_child/old, 5to10_child*, and *3to5_child/young*) and *Strollers*, involved in *Playing* activities in the *Playground* area. The fact that Group_men (red cluster) and Group_women (blue cluster) are relatively close to each other in the network may suggest that, although clearly defined, the pattern of use belonging to the blue cluster, might not be as exclusive for women as in Three Chimneys and St. Pau Gardens.

DISCUSSION

Three urban public places in the city of Barcelona have been analyzed with the aim of recognizing patterns of use disclosing gender differences, which included St. Pau del Camp Gardens, Three Chimneys Park, and Pegaso Park. Based on an innovative combination of observational methodology and network analysis, several patterns of use of the public space were identified based on

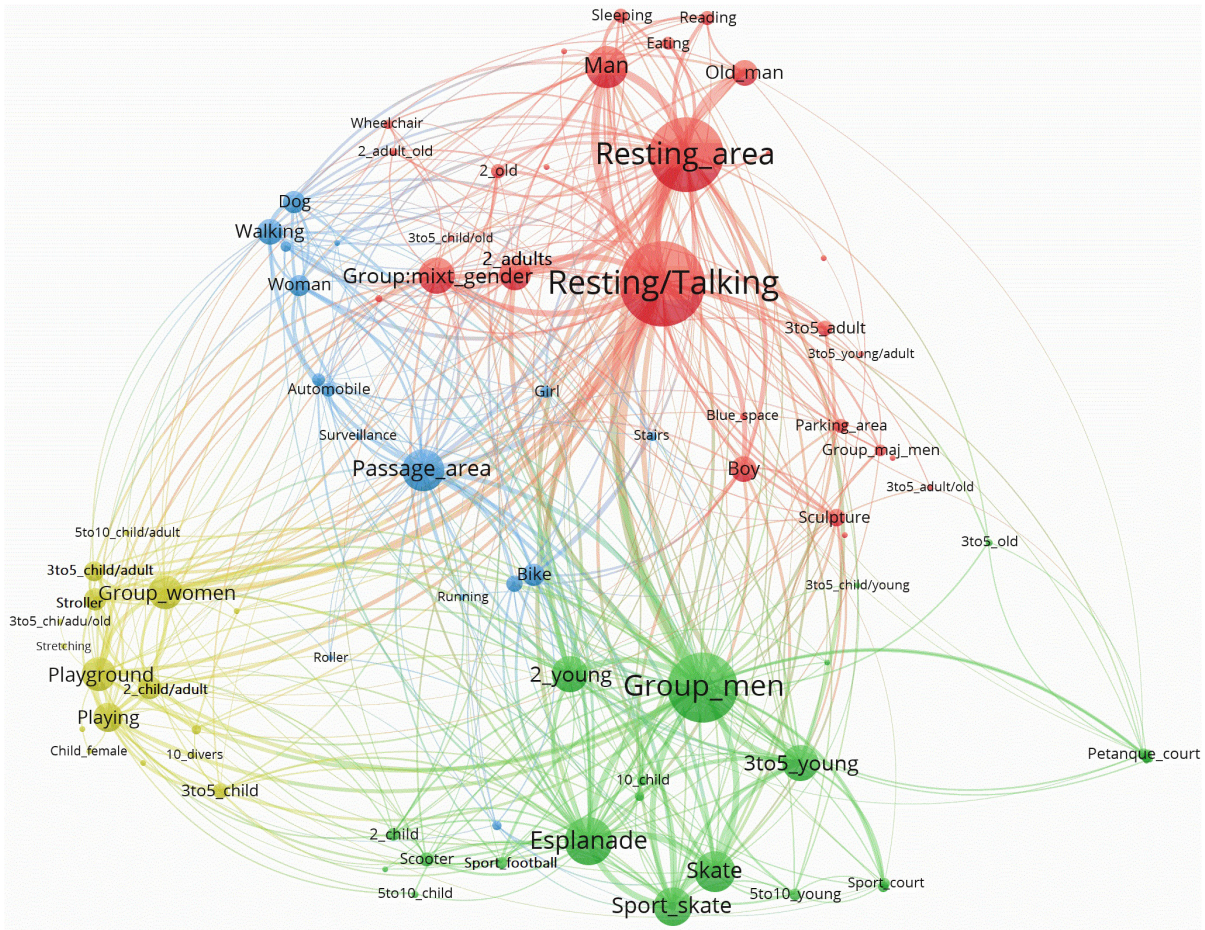

FIGURE 6 | Three Chimneys Park's network by VOSviewer.

the gender profile of users, the occupancy of different functional areas, and the type of activity associated with them.

Firstly, general attributes of the networks such Network Density, Average Degree Index, or Centralization Network Index were found to be similar among the three networks. Technically speaking, all networks were similar, although they can vary in size (number of nodes and lines). Similarities were also detected when exploring the structure of the nodes within the networks. As a result, interesting regularities can be drawn.

People use to be in public places in the group, where male groups are generally predominant. Although the presence of lonely people in all areas was less frequent, in most cases there were male users. Whereas the occupation of the public space by women was preferably in playground areas, generally involving care activities concerned with children, men were found in resting and sports areas, either practicing sports or participating in leisure activities. Bearing in mind that the central activities identified in the observed places dealt with resting (by solitary people) or resting and talking (by groups of people), it is suggested that the main areas in which users were located have been characterized by a substantial presence of males. From the perspective of gender, another important activity such as walking was more balanced, although men used to be in the majority. These results are consistent with extant literature. As acknowledged previously (Franck and Paxson, 1989; Bondi and Rose, 2003; Neaga, 2014), there is a general tendency to relate certain activities and areas of use of the analyzed public spaces to the type of genre. Accordingly, women use to be associated with care activities, especially with children, and men with resting, sports, and leisure activities. Indeed, traditional patriarchal roles seem to contribute to the informal segregation of the public space yet (Blackstone, 2003). In spite of the changing times, as Koen and Durrheim (2010) noted about racial segregation, deeply inoculated social structures still appear informally when examining urban place dynamics. In line with Cao and Kang (2019), we showed that both men and women use to be in groups rather than alone; based on this, their activities and patterns clearly differ. Solitary people (predominantly men) tend to be in resting areas or walking in passage areas, often accompanied by dogs. Encounters of both groups of men and groups of women use to take place in resting areas to talk as well. However, unlike single persons, they occupied playgrounds (mostly women) and leisure areas such as sports courts, green areas, or blue spaces (mostly men). These gender differences are consistent with

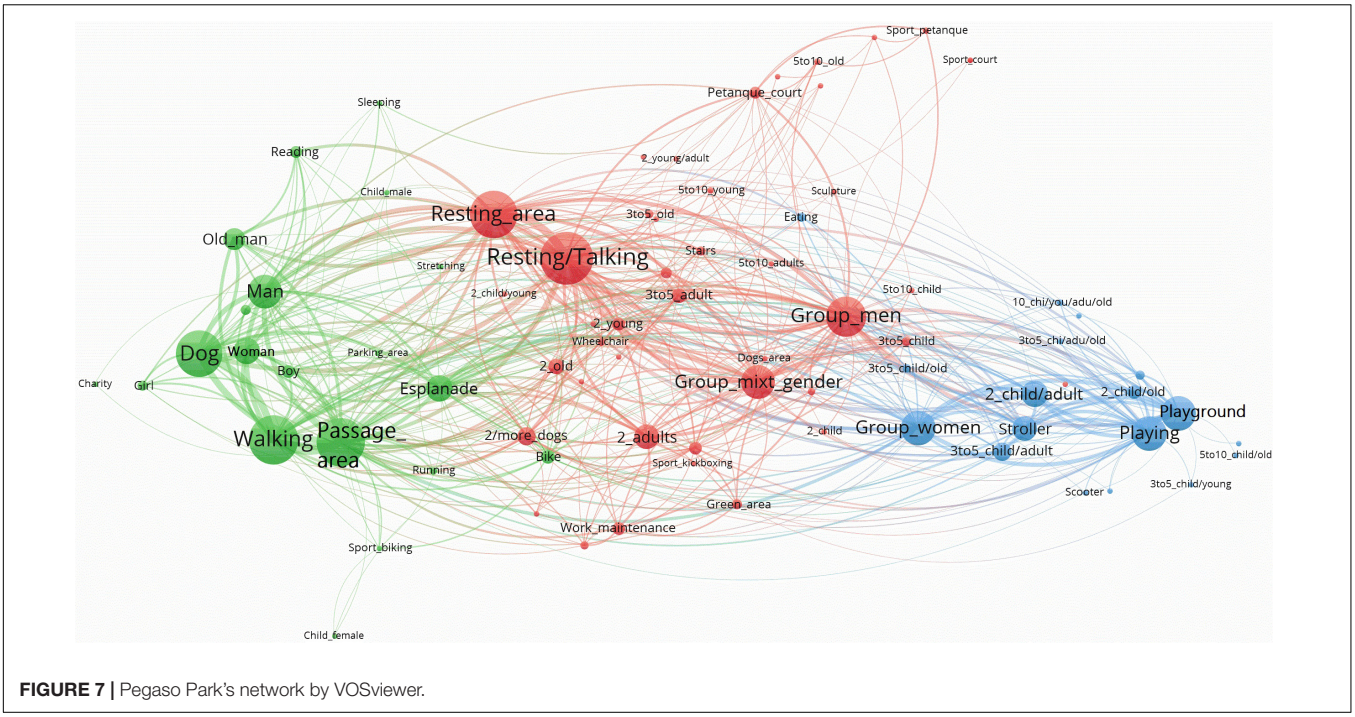

FIGURE 7 | Pegaso Park's network by VOSviewer.

inequalities in the time spent by men on leisure activities (Codina and Pestana, 2019). According to these scholars, men spend more leisure time than women, while women have more positive leisure experiences. In this sense, in his analysis of Nordic cultures, Thrane (2000) claimed that during weekdays Danish, Swedish, and Norwegian women have less leisure time than their male partners, and these findings could be interpreted as in support of women's double day effect.

Furthermore, differences in the design of the three urban sites can explain specific effects. For instance, the big esplanade in the Three Chimneys Park was found to be an attractive space for skaters. Skating is a different and a contemporary sports activity that makes this park unique compared to the other sites. However, most young men practiced it, with minimal participation of young women. This situation suggests that gender marginalization not only occurs in adults but also in young people, even when referring to a relatively new activity. The effect in skateboarding practice has been noted even in countries associated with high levels of gender equality such as Sweden (Bäckström, 2013). Once again, this supports the view about preestablished patriarchal roles regarding the informal segregation of certain activities.

A different pattern of use was observed in Pegaso Park. Due to its large extension and the variety of urban elements it contains (e.g., green areas, water areas, a long esplanade, an extended playground, and a petanque court) patterns according to gender were less intense. For example, the presence of men and women in areas concerned with activities such as resting, talking, walking, or leisure were more balanced than in the other sites. Compared to the other two cases, it is possible that the large variety of spaces and activities contributed to creating an intertwined network characterized by a complex use of the space (Park, 2020). For instance, Pegaso Park is the site that accommodates the largest number of sports activities. This complexity may have positively affected the fair appropriation and use of the public space. According to Dougherty (2006), an urban design that promotes a large variety of uses will promote psycho-environmental processes such as place attachment or spatial identity. This is because "identity and use are inevitably linked: much of a space's identity depends on the uses that take place there and whether or not the space meets the needs of its users. In the same way, a space will not be used unless people can identify with it and feel a connection to it." (op.cit, pp.II). Of course, such processes include gender identity: when variety is scarce, gender identarian connection is more restricted, and a specific gender occupation of the space can be prominent.

Similarly, with Three Chimneys Park, St. Pau Gardens' network represented three clearly differentiating patterns related to single persons, groups of men, and groups of women, respectively. Conversely, in the latter, the activities and functional areas identified were more restricted than in the former: men (alone or in group) monopolize the resting area, while women in group were located in the playground. These findings suggest the existence of a kind of socio-spatial boundary that can be explained in terms of violence prevention against women. In this line, in a study about six public places in Barcelona, Pérez-Tejera et al. (in press) showed that women perceive these two public places as highly unsafe, St. Pau Gardens in particular. Such a perception can explain why women restrict their presence in public realms such as playgrounds, where they stay in the group.

To sum, the results confirmed that, despite the progressive consolidation of feminist urbanism as an influential line of thinking in urban planning and design, patterns of use in the public realm derived from traditional gender roles remained

clearly recognizable. Therefore, from a gender perspective, a contribution of the study is that it informed about the main factors of the public space that reconfirmed the existence of such traditional patriarchal roles in our society – specifically the Catalonian society, as well as the importance of analyzing the public space as a key scenario where social aspects are explicitly exposed.

From a methodological perspective, processing observational data with network analysis techniques was shown to be relevant and adequate to tackle the intricacies of urban place analysis. The main advantage of this approach was that it allowed the collecting of large amounts of observational data straightforwardly. In comparison to more classical systems and approaches, network analysis enabled us to recognize and understand complex systems composed of numerous variables and relationships in a rather intuitive manner, which makes it a convenient instrument for architects and urban designers.

Therefore, implications for urban planning, urban design, and architecture can be suggested. From the perspective of these disciplines, public spaces must be considered key physical and functional components of the urban structure (Cudny and Appelblad, 2019). The urban public space is a never finished outcome of permanent change and adaptation. Through a proper comprehension of the urban phenomenon, designers and urban planners can positively influence the vitality of the public space. To this aim, they must be aware of how design affects the way people use and appropriate public spaces, and what activities they carry out there (Pasalar and Dewey Hallowell, 2019).

In the present study, we showed that the network analysis approach enabled us to easily and efficiently represent, analyze, and learn about the dynamics of the three case studies. In particular, it allowed us to gain a deep insight into the different patterns of space occupation and use in the different public spaces in terms of gender. Based on these, we propose that the network analysis tool can be integrated from the earlier stages of the urban planning and urban design process. In the first stage, this methodology should be used to collect objective complex data directly from an urban space under consideration through rigorous observation techniques. Then, this information can be visually represented and analyzed to identify the main patterns of use and to make a diagnosis about the suitability of the physical and functional features of the space. Eventually, the analysis of a large sample of public spaces will provide evidence about the existence of repetitive patterns (e.g., the profile of the user, type of space, and type of use or function), which may help understand and predict the extent to which the design of an urban realm may satisfy the users' needs and requirements. Finally, the outcome of the network analysis tool will be critical to supporting future design interventions in the urban space. Urban design is a field that often deals with wicked problems and situations (Simon, 1984), which due to their complex and ambiguous nature are difficult to perceive, understand, and tackle. During the urban design process, designers and urban planners need to make assumptions and define initial requirements and goals, as well as clarify intentions and design ideas. They then construct problem situations that will lead to the development of design solutions (Cross, 2011). It is at this stage that the data collected and processed using network analysis can be integrated to help designers and planners define design priorities and frame design situations. Frames are critical structures of belief, perception, and appreciation (Schon, 1995). Accordingly, framing defines the boundaries of a design and guides subsequent logical design decisions (Dorst, 2015). Due to its processing and visual representation power of complex information, the network analysis approach can play a fundamental role in supporting the framing and decision-making process of designers and urban planners at this stage of the process.

There are several limitations to this study. Among them, is the inability to access qualitative relevant information. Although non-participant observation is a convenient technique to identify human behaviors in the public realm, it is not suitable to gain access to the users' views about their reasons, preferences, and limitations for the use of the space. Accordingly, the use of mixed methods seems to be promising for future research. The use of Network Analysis in these environmental contexts is very incipient yet. Not much is known about the interpretation of centrality (referred to as nodes) and centralization (referred to as networks) indexes applied to urban life. In this study, we used some of these indexes, but their ability to inform about the social dynamics of the public places has yet to be explored. Finally, this work should be seen as a first step in studying patterns of use in the public space from an intersectional perspective. Although a major focus was set on gender analysis, we are aware of the importance of considering other identity adscriptions such as age, social status, or ethnicity, which is a combined analysis may contribute to gaining deeper insight into the use of the public space. Indeed, intersectionality is a key concept to be considered in research to come dealing with the social and urban design quality of public places in larger detail.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

SV has collected and analyzed the data, collaborated in the discussion of the results, and wrote the first version of the manuscript. HC has participated in the theoretical framework of the study, collaborated in the discussion of the results, and wrote and corrected the final version of the manuscript. Both authors contributed to the article and approved the submitted version.

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A Qualitative Study on Emotions Experienced at the Coast and Their Influence on Well-Being

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Coastal environments are increasingly shown to have a positive effect on our health and well-being. Various mechanisms have been suggested to explain this effect. However, so far little focus has been devoted to emotions that might be relevant in this context, especially for people who are directly or indirectly exposed to the coast on a daily basis. Our preregistered qualitative study explored how coastal residents experience the emotions they feel at the coast and how they interpret the effect these emotions have on them. We conducted semi-structured interviews with a purposive sample of eight Belgian coastal residents aged 21–25 years old. The interviews were analyzed with the approach of interpretative phenomenological analysis. Five superordinate themes were identified and indicate that, for our participants, the coast represents a safe haven (1) in which they can experience emotional restoration (2), awe (3), and nostalgia (4). These emotional states are accompanied with adaptive emotion regulating strategies (5), such as reflection and positive reappraisal, that may facilitate coping with difficult thoughts and feelings. Our study demonstrates the importance of investigating specific emotions and related processes triggered at the coast and how these could contribute to the therapeutic value of the coast.

Keywords: restorative environments, blue space, emotions, well-being, interpretative phenomenological analysis

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INTRODUCTION

Throughout recent years, there has been an increasing amount of research demonstrating multiple health and well-being benefits from exposure to blue spaces, i.e., natural environments that feature water (Gascon et al., 2017; White et al., 2020), with a particular focus on coastal environments. Although the coast has been visited by people for leisure, relaxation and thalassotherapy already since the 18th century (Verhaeghe, 1843; Strange, 1991), it is only until recently that there is empirical evidence of the relationship between the coast and well-being. Much of this evidence has demonstrated that residential proximity to the coast is associated with a better physical and mental health in comparison to residents living inland (Garrett et al., 2019; Hooyberg et al., 2020).

Various factors have been suggested to contribute to the well-being benefits of living near the coast. For example, coastal proximity is positively associated with the likelihood of achieving recommended guidelines of physical activity a week (White et al., 2014). Coastal environments are also seen as areas that boost social interactions (Ashbullby et al., 2013) and spending time with family and friends is stated as a key motivation for visiting the coast (Elliott et al., 2018). Furthermore, several environmental factors can explain the positive effects of the coast on well-being such as temperature regulation (Völker et al., 2013) and sea spray aerosols (Van Acker, 2021). Finally, coastal environments are considered as restorative in terms of stress reduction (White et al., 2013) and restoration of depleted cognitive abilities (Gidlow et al., 2016).

Considering the suggested mechanisms underlying the relationship between the coast and well-being, research has hitherto mainly focused on physical, social, and cognitive factors whereas emotional factors remain ambiguous. To create a more comprehensive framework of how and why the coast benefits well-being, it is imperative to also consider potential emotional processes. Although various emotional processes related to the coast have been suggested by earlier studies (Bell et al., 2015), the exact nature of these emotions and their effect on our well-being remain unclear. One way to investigate these emotions is to look at how people experience their emotions when they are at the coast. Nonetheless, the majority of qualitative research on emotions at the coast were conducted with visitors or tourists (Willis, 2015; Jarratt and Sharpley, 2017; Pearce et al., 2017), and not coastal residents. Due to the direct or indirect exposure to the coast on a daily basis, we can question whether coastal residents experience similar emotional processes at the coast, or perhaps to a lesser degree. To fill this knowledge gap, the present study is therefore based on the following research question: how do coastal residents make sense of the emotions they experience at the coast and of how these emotions affect them?

The Coast as a Therapeutic Landscape

The relationship between the coast and well-being can be set within the concept of *therapeutic landscapes*, defined by a landscape where "physical and built environments, social conditions, and human perceptions combine to produce an atmosphere which is conducive to healing" (Gesler, 1996, p. 96). In other words, a therapeutic landscape can be any place with physical and social features that enable physical, mental, and spiritual well-being, as perceived by the people engaging in it.

Blue spaces, and thereby coastal environments, have been investigated as therapeutic landscapes (Völker and Kistemann, 2013; Bell et al., 2015; Finlay et al., 2015; Foley and Kistemann, 2015; Satariano, 2019). These studies explored three key dimensions of therapeutic landscapes experienced at the coast, namely the physical dimension, the social dimension, and the symbolic dimension (Gesler, 2003). The physical dimension relates to the diverse set of activities that the coast offers and its associated benefits. Participants from the study of Bell et al. (2015) described that these activities can fulfill a desire for challenge and achievement and provide emotional and cognitive release. Swimming, for example, has been shown to have a beneficial effect in the treatment of chronic disorders such as rheumatism or arthritis (Foley, 2010) and is known to support the maintenance and recovery of health (Foley, 2017). The social dimension refers to the opportunities for planned or spontaneous social interactions at the coast, as well as a collective experience of nature that enables a sense of community and social identity (Finlay et al., 2015). In addition, the coast is considered to be of intergenerational value as it has been shown to be beneficial for all age groups, containing an atmosphere of play and relaxation (Ashbullby et al., 2013; Satariano, 2019). The symbolic dimension of therapeutic landscapes relates to the historical, cultural, and individual perceptions of the coast and its effects on well-being. For example, in Bell et al. (2015), perceptions of water as cleansing or purifying conditioned the participants' experience with coastal waves and associated moods and emotions. Besides individual perceptions of the coast, different cultural notions and traditions most likely also influence how specific communities interact and experience the coast and its effects (Wheaton et al., 2020).

Emotions at the Coast

One dimension pertaining to the therapeutic landscapes concept that has not been specifically looked into is the emotional dimension. Only a handful of studies explicitly focused on emotional processes linked to the coast (Willis, 2015; Jarratt and Gammon, 2016; Jarratt and Sharpley, 2017; Pearce et al., 2017). In these studies, two emotions are prominent, namely the emotions of awe and nostalgia. Awe is an emotion that occurs whenever one perceives something as larger than the self and when one feels the need for accommodation to assimilate it (Keltner and Haidt, 2003). It is an emotion that is characterized by feelings of a small self, in which one's attention is less focused on the self (Shiota et al., 2007) and one's personal concerns and goals become less significant (Piff et al., 2015). Typical stimuli that elicit awe include art, music, and natural landscapes with panoramic views (Shiota et al., 2007). The coast in particular appears to trigger awe, accompanied with a change in perspective and feelings of relaxation (Willis, 2015; Jarratt and Sharpley, 2017). In a study by Pearce et al. (2017), when asked about what inspires awe at the coast, participants replied with five different facets: marine fauna, aesthetics, ecological phenomena, vast geological landscapes and reflective moments.

The second prominent emotion, nostalgia, is characterized by a sentimental yearning for the past, and although historically considered to be an emotion of negative affect (McCann, 1941), it is increasingly being regarded as ambivalent, thereby containing both positive and negative affect (Sedikides and Wildschut, 2016). Nostalgic experiences are associated with redemption (Wildschut et al., 2006), whereby the narrative progresses from a negative standpoint into a positive one, e.g., taking the good out of the bad (McAdams et al., 2001). In relation to the coast, the study by Jarratt and Gammon (2016) showed that seaside visitors feel nostalgic during their visits to the coast, due to the unchanging and timeless nature of the coast, in contrast to the fast-paced modern world. In addition, nostalgia

can be triggered by sensory input (Wildschut et al., 2006), in line with findings that tastes and scents can elicit autobiographical memories (Chu and Downes, 2000). The coast most likely provides sensory stimuli that can lead to nostalgia, such as the scent of the ocean (Reid et al., 2015).

Both awe and nostalgia are considered as complex emotions, namely that they are a combination of two or more emotions. Nostalgia, for example, can be regarded as an aggregate of sadness and happiness (Power, 2006) and awe can be perceived as a mix of fear and happiness (Arcangeli et al., 2020). Moreover, awe and nostalgia are shown to positively affect well-being. Within the context of eudaimonic well-being, which defines well-being with such concepts as autonomy, environmental mastery, personal growth, positive relationships, purpose in life, and self-acceptance (Ryff and Keyes, 1995), both emotions contribute to meaning in life (Routledge et al., 2012; Danvers et al., 2016). Nostalgia has also been shown to enhance self-esteem and social connectedness (Hepper et al., 2012; Reid et al., 2015). Within the context of hedonic well-being, considered as a state of positive affect and absence of negative affect (Kahneman et al., 1999), studies find that nature-induced awe is associated with life satisfaction (Anderson et al., 2018) and is negatively correlated with boredom (Severin et al., 2021). Nostalgia is also shown to buffer against boredom (Van Tilburg et al., 2013) and to generate positive affect (Wildschut et al., 2006). Considering the positive effects of awe and nostalgia on well-being, it is possible that experiencing these emotions at the coast contributes to the role of the coast as a therapeutic landscape.

An additional mechanism that can pertain to the emotional dimension but does not relate to an emotion *per se* is psychological restoration, defined as a renewal or recovery of depleted physical, psychological, and social resources (Hartig, 2004). More specifically, emotional restoration relates to feeling calm and relaxed as well as feeling refreshed and revitalized. Studies show that visits to natural environments, and particularly the coast, lead to greater emotional restoration (Hartig et al., 1991; White et al., 2013). A prominent theory related to this phenomenon is the stress recovery theory (SRT; Ulrich et al., 1991). The SRT posits that, compared to an urban environment, an environment with natural features facilitates positive affect—notably feelings of interest, pleasantness, and calm, and also reduces both physiological and psychological stress, due to an innate affinity toward nature (Ulrich, 1983). Aquatic features in particular seem to provide greater restoration in terms of relaxation and positive affect (Ulrich, 1981; White et al., 2010). Emotional restoration can therefore also be an important mechanism in in the relationship between the coast and well-being.

Present Study

The present study aimed to provide an in-depth analysis of how coastal residents experience the emotions they feel at the coast and how they interpret the effect these emotions have on them. To do so, we conducted semi-structured interviews with a group of young Flemish adults who grew up near the Belgian coast and/or were currently residing near the coastline. This particular age group was chosen due to the multiple stressors young adults are exposed to (e.g., instability in work and relationships, transition to living apart from parents, identity exploration) and their resulting mental health implications (Arnett et al., 2014). We subsequently analyzed the interviews with the approach of interpretative phenomenological analysis (IPA; Smith et al., 2009).

MATERIALS AND METHODS

Our study's aim, design, and analysis plan were preregistered on the Open Science Framework (OSF) registry before data collection.[1]

Participants

In line with the principles of IPA, which will be discussed further, we recruited a purposive homogeneous sample of eight participants. The authors of IPA consider an acceptable sample size to be between four and ten participants (Smith et al., 2009). Inclusion criteria involved being between 18 and 25 years old and living near the Belgian coast. A description of the eight participants can be found in **Table 1**.[2] All participants were from the region of Flanders and therefore the interviews were conducted in Dutch.

Procedure

Two participants were recruited *via* advertisement of the study in a university school in Ostend, Belgium, whereas the rest of the participants were recruited *via* word-of-mouth. Participants were notified of the study's inclusion criteria, its aim to explore how coastal residents experience living near the coast, and the registration procedure. Upon registration, participants were asked to fill out an informed consent form. Interviews were then conducted *via* Skype, during the months of October to December 2020, to respect measures against the COVID-19 pandemic at that time. The interviews lasted between 40 and 60 min and were digitally recorded, transcribed and pseudonymized. After the interview, participants received a financial compensation of 15 euros (approximately 17 USD). The study was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University.

The semi-structured interviews followed a predetermined interview guideline that consisted of 13 open questions (available at https://osf.io/v2cax/). Participants were first asked to introduce themselves and provide insights into their daily routines to put them at ease. They were then asked to describe their relationship with the coast and the impact of living near the coast on their daily lives. Finally, they were asked about the specific emotions they feel at the coast and what effect these emotions have on them. Extra prompts were prepared and sometimes used to facilitate further discussion, such as asking

[1]https://osf.io/tm7pj

[2]Each participant's name has been replaced by a pseudonym to protect confidentiality.

TABLE 1 | Participant characteristics.

Participant pseudonym	Sex	Age	Living situation	Studies/work	Extra characteristics
Arne	Male	*MV*	Grew up and is living near the coast	Student	Diagnosed with autism spectrum disorder
Emma	Female	22	Grew up near the coast and lives inland in student room	Student	
Justine	Female	22	Grew up near the coast and lives inland in student room	Student; on Erasmus in another country	
Noa	Female	22	Grew up and is living near the coast	Temporarily employed; seeking work	Diagnosed as a highly sensitive person
Anna	Female	22	Grew up near the coast and lives inland in student room	Student	
Louis	Male	22	Grew up near the coast and lives inland in student room	Student	
Laura	Female	25	Grew up inland and lives near the coast	Employed	
Victor	Male	21	Grew up and is living near the coast	Student	

MV stands for "missing value." The participant Arne did not inform us his age.

whether the emotions are accompanied with particular physical sensations or thoughts. This guideline helped to steer the conversation toward the questions of interest. Nonetheless, we aimed to leave space for participants to share their story and to bring up new areas that were not considered before. This type of interviewing enables more flexibility to explore participants' interests or concerns and facilitates a rapport between the researcher and participants (Smith and Osborn, 2015). In order to familiarize themselves with this kind of interviewing, each researcher conducted a pilot interview with an external person that was unaware of the study's aim.

TABLE 2 | Step-by-step procedure for interpretative phenomenological analysis.

1. Read and reread transcript of interview and make descriptive, linguistic, and conceptual notes.
2. Develop emergent themes based on the notes and the transcript.
3. Cluster themes together to create a table of overarching themes.
4. Repeat steps 1–3 for each participant, with the conscious attempt to minimize the influence of the analysis of the previous interviews.
5. Compare the individual table of themes with each other: similarities, differences, and patterns between transcripts are noted.
6. Construct a final table of superordinate themes that stems from all participants and includes individual exceptions.

Qualitative Data Analysis

The transcribed interviews were analyzed with the use of IPA. The aim of IPA is to investigate in a detailed manner how participants make sense of a specific phenomenon or experience and the meanings that they attach to it. IPA is thus an ideal approach for our study as it focuses on the lived experience of a particular group and is best suited for research questions that are understudied (Peat et al., 2019). IPA is constructed around three principles: phenomenology, hermeneutics, and idiography. Based on phenomenology, IPA researchers strive to look into participants' subjective experience rather than make an objective statement of the experience itself. However, the principle of hermeneutics shows that access to this experience depends on participants' interpretation of it as well as the researcher's interpretation of the participants' interpretation. In opposition to the nomothetic approach, the last principle, idiography, dictates that IPA researchers prioritize an analysis on a case-by-case basis and therefore avoid making premature general claims for larger populations. Purposive sampling is thus used to find a "more closely defined group for whom the research question will be significant" (Smith and Osborn, 2015, p. 56).

In our study, we employed IPA using a step-by-step procedure demonstrated in **Table 2** (Smith et al., 2009). Each interview was analyzed individually, before being compared with each other. This individual analysis consisted of first familiarizing oneself with the interview by making descriptive, linguistic, and conceptual notes. An example of a linguistic note was to notice a participant anthropomorphizing the sea ("that is something that the sea never asks"), which indicated perceiving the sea as a powerful entity. We then identified emerging themes based on connections among these interpretative notes, such as "the coast representing home," or "fascination towards the sea." These subthemes were subsequently clustered into five or six overarching themes that conceptually differ and that are prevalent in the interview. Each theme or subtheme is illustrated by one or several direct quote(s) of a participant. This process is repeated for each participant, with the conscious effort to put aside the analysis of the previous cases, known as "bracketing" (Peat et al., 2019). The final step involved a group analysis to construct a final table of superordinate themes, based on the themes of each participant. Some themes were found for every participant and thus shifted into superordinate themes, while other themes were clustered to create one new theme. This final table of themes represents the findings of our study.

While conducting IPA, we aimed to respect reflexivity, which is the process of being aware of how the perspectives and beliefs of the researchers might influence the analysis procedure (Dodgson, 2019). The transcripts of the interviews were analyzed by two Master students (EN and LL) and one doctoral student (MS), under the supervision of a professor (AB). Although the authors enjoy visiting the coast, neither of them has or has had a permanent residency near the coast. One of the authors (EN) did live in a coastal city while practicing surfing for 6 months and experienced this very positively. Nonetheless, the analysis process was done in collaboration between the

authors. Several meetings took place in which the authors discussed the findings. The first transcript was analyzed by all the authors, with the joint construction of its table of themes. The remaining transcripts were analyzed separately, and the final table of themes was subsequently set up together. In this way, the interpretation of the interviews could not be based on an individual researcher perspective and conscious effort was made to not impose personal feelings toward the coast during these collaborative discussions. According to the framework of Yardley (2000), rigor was achieved by implementing this reflective process, the use of bracketing and pilot interviews, and ensuring a sample that was appropriate for our research question.

RESULTS

The IPA results of our semi-structured interviews consist of five superordinate themes: emotional restoration, awe, nostalgia, emotion regulating strategies, and the coast as a safe haven. The themes are presented in the following sections. We would like to emphasize that the interviews and analysis were conducted in Dutch and therefore all quotes from participants have been translated to English.

Emotional Restoration

The coast appears to have an emotionally restorative effect on our participants as they all described feeling calm or revitalized when visiting the coast. This effect was however expressed differently by each participant. Justine, for example, spoke of "feeling reborn" when she is at the coast and claims that spending time at the sea makes her feels more "recharged" and is "more effective than watching a TV series for 20 min." For Noa, being at the coast calms her down and brings her "peace of mind." Some participants compared the coast with urban environments, such as Louis who stated that he feels calmer at the coast "because in any case in a city, there is often more movement, more people, and more stimuli." The feeling of calmness appears to come from the availability of open space and the accompanied opportunities to do physical activity: "by the sea you can just walk or cycle meters on the beach, and you just immediately calm down a bit" (Louis). For other participants, simply seeing the coast brings them a feeling of calmness.

> Emma: "I often feel that I only really relax when I have seen the sea. Then, I feel it so almost physically that something falls off of me or something …, even if it is sometimes only for five minutes just having seen the sea that does a lot, yes that really means a lot."

The restorative effect of the coast can be especially prominent during certain stressful moments. For example, Anna typically enjoys relaxing near the sea during exam periods. For Emma, going to the coast "always helps" when she "feels a lot." She adds that although this does not solve anything, "it does help because it calms me down." Furthermore, in comparison to the other participants, Laura indicated that feeling calm at the coast happens only occasionally for her, notably when she is alone or "when it has been a busy day at work or you have a headache or something." The feeling of calmness that the coast brings also seems to decrease during the summer due to increased tourism. Laura, for example, expressed that "in the summer I have in any case the opposite I think, then the sea makes me much more nervous than [name of city] would make me." Tourism therefore seems to reverse the soothing effect of the coast for several participants.

Awe

During the interviews, almost all participants spoke to some extent about an overwhelming effect of the coast on themselves that seems to reflect the emotion of awe. A contrast emerged between awe with a positive valence and awe with a negative valence. Positive awe was expressed by some participants as a fascination for the sea and its natural elements and a respect for its power and grandeur: "the sea is also very fascinating because when you stand by the sea and you listen to the noise that the sea makes, you know that there is an enormous power within it." (Arne). The interplay between different natural elements and sensory stimuli could make a deep impression on some participants. Justine, for example, was particularly impressed by the vastness of the coast; she stated that the sea is "such a large body of water that we do not control." The dynamic aspect of the coast was also referred to by some participants, such as the infinite repetitive motions of the waves, the "color changes" of the coast as well as the tidal changes, "the ebb and flow." Several participants also mentioned the particular beauty of other natural phenomena of the coast such as the "blue algae in the waves," "waterspouts," "snow on the beach," and "beach insects." Furthermore, the power of the sea was an important element in triggering awe for some participants. A feeling of adrenaline and excitement was described when faced by a stormy sea.

> Justine: "When it storms, I love to go for a walk on the beach. Even though they often advise against that (laughs), but uh, I think it's really cool to see that – yes, I think that's something really overwhelming, the sea."

Louis, who works as a beach lifeguard, also described an awareness and appreciation of the dangerous elements of the sea. For Arne, it is the "science" behind the sea that fascinates him, such as the sea's regulation of temperature, as well as the battle between the sea and manmade constructions at the coast, in which "construction sometimes wins, sometimes loses to nature."

In contrast to feeling positive awe at the coast, certain participants expressed awe in more negative terms, particularly toward the mystery and the grandeur of the sea. Victor, for example, finds it "frightening" to "go really deep into the water" and Laura expressed displeasure of not being able to "see what's happening at your feet" when she's in the water. Both

participants also conveyed fear toward the grandeur of the sea, especially during a storm.

> Victor: "I find it scary sometimes, because it's so majestic, it's so big, and then when there's a lot of wind and high waves and stuff, I can be impressed by that, and that can instill a certain fear in me."

This sort of negative awe can perhaps be due to not being able to fulfill the need for accommodation. Indeed, certain participants described trying to understand the grandeur and mystery of the coast. For example, Arne tries to comprehend how the strength of the sea does not break the pier: "how in God's name is it possible that the pier and the railing all remain standing when those waves crash into them." Victor also displayed his reflections over the history of the coast and what lies beneath the horizon. Nonetheless, Louis depicted an example of how negative awe can lose its negativity through frequent exposure to the coast:

> Louis: "if you often go into the sea and you become a bit used to what those dangers are, or you know what to do and such, … you do get a little less frightened or something, and it becomes less threatening."

Louis was therefore able to adapt his mental schemas concerning the threatening elements of the sea and thereby feel less fear.

Moreover, the emotion of awe at the coast appears to have certain effects on the participants. These effects could be in the form of physical sensations or specific feelings that portray an emotional impact upon the participant.

> Victor: "you can get a shiver down your spine … if you're so impressed by that situation or something. Or I'll then get a lump in my throat, or there can be once a (laughs) – a tear rolling down …, I can be caught off-guard like that yes."

In addition to these physical sensations, awe also seems to lead to a feeling of small self, as stated by Arne: "the grandeur, the greatness of the beach, of nature, of the dike … and then you just stand there as a small, small dot, yea then you just feel very humble and from there you start thinking about life." Furthermore, for other participants, the emotion of awe facilitates a feeling of calm, such as for Laura who "calms down" when she "can enjoy the fact that it [the coast] is beautiful."

Nostalgia

In addition to awe, the coast seems to generate nostalgia in participants by evoking important memories that were created there. All participants described unique memories of the coast throughout their lives. The majority spoke positively of these memories with a nonverbal behavior that portrayed pleasure and gratitude (e.g., laughter, smile). Nonetheless, some participants recalled memories that appeared to be negative. Anna, for example, recounted the death of a family friend who used to take photos of the coast and she thereby sometimes thinks back to that event while at the coast. She further expressed how this makes her feel sad but that "it's ok" and that being at the coast makes her feel more "calm" because the "sound of the sea is also calming." Thinking back to this memory is therefore bittersweet as Anna experiences both sadness and a "beautiful" feeling.

A great deal of the memories described by participants were socially-oriented. Examples involve activities with friends and family such as parties in the evenings, walks on the beach, summer vacations, games and watersports. However, some of the memories were not focused on social features and were instead directed toward natural phenomena at the coast. For example, Arne and Noa longed for the winter, and more specifically, snow on the beach.

> Arne: "the best memory was when it still snowed at the coast …, that the beach was sometimes a bit white and so was the dike, yea just these idyllic pictures …, yes these are the memories I cherish the most about the dike and the sea."

Additionally, storms at the coast seem to trigger important moments that involve challenging one's own boundaries. Noa, for example, talked about an enduring memory, when she swam in the sea with her younger brother on a stormy evening, and emphasized the "rush" and adrenaline that she felt. Other memories associated with the coast that were not socially-oriented were memories of daily routines at the beach such as walking the dog or watching the sunset. Walking at the coast seems to arouse nostalgia in Arne when he thinks about all the "beautiful moments" he spent with his dog at the beach and he wonders "how much longer they can still enjoy" these moments. Justine also expressed missing the coast and her routines there as she was on an Erasmus exchange in a city with a strict lockdown and had no access to the coast at the time of the interview.

The coast appears to play an important role throughout the lives of the participants as they described enduring memories of the coast from their childhood and teenage years. For example, Laura mentioned how she, as a child, did things like "every child": "sit on the beach and sell those flowers and go look for shells." Teenage years were then described as "pretty fun days, young teenage days …, days playing with friends at the beach, playing in the sea" (Noa). Many of these memories were linked to summertime at the coast and its "carefreeness," which generated nostalgic feelings in several participants, as Emma mentioned missing "the whole summer atmosphere." However, unlike the rest of the participants, Arne had the least memories of the coast in his childhood. He has autism spectrum disorder (ASD) and is quickly overwhelmed when there are a lot of people; because of increased tourism, he therefore could not spend much time on the beach when he was a child and instead went more often to parks.

Apart from creating important memories, the coast also seems to trigger the reminiscence of these memories. Victor, for example, explained how being at the coast makes him remember a special moment with his friends during high school:

> Victor: "I remember that moment sometimes when I go to the beach in the summer, it reminds you of friendship and of the old days. It is unconsciously so that many things directly or indirectly have something to do with the beach, with the proximity of the sea."

Certain sensory stimuli of the coast were considered to evoke memories such as the scent of the beach that reminds Anna of the summer. For Arne, this effect of reminiscence seems important as he indicated that he "would still visit certain places regularly just to reminisce" if he no longer would live near the coast. Justine also mentioned that the many beautiful memories of the beach "play a part in the fact that she likes being there." Various feelings seem to accompany the reminiscence of memories at the coast, such as a "feeling of happiness," "a little homesick," a feeling of "loss," or a feeling that time goes quicker.

Emotion Regulating Strategies

In the interviews, various emotion regulating strategies were depicted, either in relation to the emotions mentioned above, or independently associated with the coast. Although there is clear overlap between them, we describe them separately below.

Reflection and Meaning-Making

Several participants expressed that the coast is a place where they could stand still and reflect on life, problems, and emotions: "the big questions of life then start to play out" (Arne). For Justine, it is "one of the few moments" that she thinks about her emotions. Victor also benefits from being able "to reflect on his feelings and his emotions" at the coast, because he "maybe sometimes does that too little in his daily life." He specifies that he is "not consciously" thinking about specific things but that "things are always going through his mind." In contrast, for Emma and Justine, the coast can also just be a place for them to think of nothing.

Arne emphasized that the possibility of contemplation during his "long walks" on the beach is important to him as it helps him to sort things out and to go over the "mistakes" he might have made during the day, often in the context of his ASD. Regarding these mistakes, Arne displayed signs of meaning-focused coping through acceptance as he says: "I made them [the mistakes] but I'll make sure I do not make them twice." The self-reflection that the coast offers can therefore potentially help Arne to open up to unprocessed feelings, such as guilt, shame, or frustration. Another sign of a meaning-making process is the humility and vulnerability that Arne feels when he experiences awe. As he realizes that "we are actually nothing compared to the sea," he "tries to build a philosophy in his life" in which he is humble both to nature and to other people. Other participants also described meaning-making in terms of putting things in perspective, which helps them to focus on what is truly important to them and also helps to not keep stressing for the less important things in life.

> Emma: "I also just realize more what I have, because I can be stressed about things, but in the end it's not all that important as long as you … are healthy and as long as your family is okay then, I don't know, then I can fail as many exams that I want, but that just doesn't really matter."

Letting Go and Exteriorizing Emotions

Some participants indicated how they can let go of their emotions at the coast. Two participants alluded to coastal elements facilitating this process. Noa, for example, mentioned "being able to let go of everything for a while" and her emotions could "literally slide into the earth or blow with the wind." Emma also talked about "how it all blows away from you" with reference to the wind at the coast. In relation to this, Laura indicated that the coast was the best place for the Dutch practice called "uitwaaien," which means to go outside in windy weather with the aim to clear one's mind.

In addition to letting go of emotions, the coast also helps Justine in letting go of overthinking and makes her become more aware of the present moment: "everything else that goes on in your life, then I forget that and then I'm just … one with nature." In particular, Justine expressed the importance of the coast at a time when she had to make a crucial decision, stating a constant need to be "preoccupied" with this decision, but being at the beach gave her the permission to temporarily let go of the weight of this decision. The coast therefore offers some participants the chance to get a breath of fresh air and to thereby let go of certain (often difficult) thoughts, feelings or emotions.

The coast was also considered to be a place where emotions could be exteriorized for certain participants, functioning thereby as an "outlet." Noa spoke most explicitly about this when she stated that the coast is a place where she could express her emotions, including negative emotions: "sometimes I can really let go of my anger or my sadness, so to speak, so that it can really get out." To exteriorize these emotions, Noa performs actions such as "screaming, crying, or singing." This exteriorization stops her head from "spinning" and has a positive effect on her: "it calms me down, gives me peace of mind, gives me sometimes just the energy, to keep going." The use of the coast as an outlet helps Noa to move forward, so that she "no longer has to think about it" and instead think: "tomorrow is a new day."

Seeking Experiences of Peak Flow

The use of the coast as means of stimulation and seeking peak flow was demonstrated in two participants. Noa, for example, described at length how she uses the coast to pursue a "rush." During her childhood, the coast gave her a place to "romp," or in other words to play around in a lively manner, and to "seek out adrenaline rushes." As Noa grew older, she started to do watersports such as kitesurfing, with which she would seek out "the challenges" and the "combination of wind and sea to then get the feeling thereof."

> Noa: "Feeling for me is really just being able to feel with all the sensors that I have without being directly overwhelmed, so in nature for me there is always a sort

> of vibe, a fixed wavelength … with which I can surf along. That also gives a secure peace of mind or a mental calmness."

This type of experience can be referred to as an experience of peak flow. Noa related this experience to her being a highly sensitive person and thereby demonstrated that doing kitesurfing, or "moving flexibly her legs on the sea, absorbing these shocks," helps her cope with her high sensitivity.

Arne also displayed how the coast is a place that positively stimulates him. As he described the fascination he feels when he sees the water hit the pier during a big storm, this does not negatively overwhelm him such as other stimuli in his daily life. On the contrary, he actively seeks out this stimulation as he explained how one time during a storm, he climbed over the fence that was used to close off the pier, to look at the water. At that time, he was "really excited" and found that "very pleasant." Both Noa and Arne thus experience difficulties with processing stimuli but named the coast as a place where they can feel safely stimulated.

Coast as a Safe Haven

The coast was described by participants in various ways as a safe haven, or in other words, a place where they could feel at ease and feel safe to experience emotions and vulnerability. This was conveyed by three different facets that are described below.

Respite From Daily Life

Several participants expressed how the coast provides them respite from the hustle and bustle of their daily lives.

> Justine: "I find that with many other things in our lives, it is always very busy …, and by the sea, or the dunes, I find a place where you can once in a while be somewhat stimulus-free and that you return to a moment of zen."

Coupled with this, Justine described how there is an absence of pressure and expectations at the coast. In her daily life, she feels like she "has to be in a hurry," that she has things to do and things she should not forget, whereas the coast offers her "some more time to think" and enables her to relax. Arne also mentioned that there is an absence of social pressure and norms at the coast: "by the sea you have time, there is no one who says 'you have to walk faster', there is no one who says 'you have to do this, you still have this much to do." Even the feeling of time itself can be absent at the coast, as Noa refers the coast as a "timeless place" and does not feel the need to look at the time when she is there.

Beyond providing respite, the coast also generates a sort of disconnection from reality for various participants. For example, Victor recounted how during his daily drive along the coastal road he can become so "lost in his thoughts" that he does not notice how far he went until he stops at a traffic light. This type of disconnection from reality was described by Emma in relation to the dunes, as she stated that the dunes make one feel really cut off from the rest of the world, in comparison to coastal cities that only have a dike.

Feeling of Safety and Freedom

An important aspect of the coast as a safe haven is the feeling of safety and freedom that the participants reported experiencing there. In terms of safety, Emma described the sea as a "very safe environment where she feels very good." Other participants also mentioned "feeling at ease" at the coast, with Justine adding that she "never feels alone," she "just always feels very reassured by the sea." This sense of safety could come from the familiarity that participants have in relation to the coast. Some participants expressed how the coast is, and always will be, there for them, as Arne said: "when you are happy, when you are sad, you can always go to the beach." Justine stated that even when she does not go to the coast, "just the fact that she knows it's there" is reassuring for her. Additionally, the coast represents "home" for some participants, like for Arne who described the sea as his "homeland." Justine even went so far to say that she "identifies with" the sea. It is therefore more likely that this familiarity with the coast explains the feeling of safety that participants feel there, rather than the coast itself. Anna even linked the two together by saying: "a sense of safety, yes, just a familiar environment actually."

In addition to creating a feeling of safety, the coast also represents a place that facilitates emotions and vulnerability. For example, Noa indicated that she and her parents use the coast to have difficult conversations with each other. The coast is thus a setting that makes these conversations easier to have for Noa. Furthermore, Arne expressed how in his daily life, he feels he needs to be as rational as possible, but at the coast "he starts to become emotional," by reflecting on life and "allowing the peace that the sea indirectly gives you." This is the "absolute opposite of the feeling" he has during the day. An element that may support this effect on Arne is the simplicity and predictability of the sea, such as the infinite repetition of its waves. The outside world may feel unpredictable to Arne, because of his ASD, and experiencing the natural predictability of the coast may help release the pressure he feels during the day: "The sea that runs its course there, comes and goes, comes and goes. The simplicity."

Some participants expressed a sense of freedom that they feel at the coast. For example, Louis described the coast as providing the freedom to "do what you want." This sense of freedom appears to have been accentuated throughout the COVID-19 pandemic for most participants. This could be due to the easy accessibility of a wide-open space, as pointed out by Victor: "we were always lucky here that the sea was close by and the beach is vast, it is large, you can walk there with many people at the same time, without walking on each other's feet." Victor also mentioned that due to the diversity of the coast, with the beach, the dunes, and the forest, "you do not have to do the same tour everyday," and this "played a positive role" on him. The coast was therefore perceived as an "extra freedom" during the first-wave lockdown, where the participants could walk or exercise.

The Opportunity to Be Alone

The opportunity to be alone at the coast also contributes to the representation of the coast as a safe haven as it is appreciated by several participants and appears to facilitate the emotion regulating strategies triggered there. For example, Noa and Arne explicitly seek out the coast when there are as few people as possible, as Noa "enjoys the emptiness when there are not many people on the beach" and Arne "just loves when you look over the length of the dike, that you really do not see anyone." Being alone at the coast may help them cope with the overstimulation that they experience in their daily life. Other participants also mentioned the calming effect of having a "moment for themselves" (Justine), with Louis stating that it is especially "when he's alone" that "he can really feel at ease." Additionally, although Laura rarely visits the coast alone, she did indicate that the calming effect of the coast was mostly present when she walked alone.

DISCUSSION

Our qualitative study presents five superordinate themes that represent the emotional experiences generated at the coast for eight Belgian coastal residents.

Emotional Restoration

The first theme relates to emotional restoration, as all participants reported feeling calm and/or revitalized when they were at the coast. This is in line with findings of a meta-analysis demonstrating a positive association between larger amounts of blue space within a geographical area and markers of restoration such as stress, anxiety, and depressed mood (Georgiou et al., 2021). For our participants, this feeling of calmness and peace of mind was linked to various coastal elements (e.g., wind, water, open space) and the opportunities for physical activity. This supports the claim that physical activity at the coast enables restoration, as emphasized by the Blue Gym initiative (Depledge and Bird, 2009). The emotional restoration experienced by participants also aligns with the stress recovery theory of Ulrich et al. (1991), as they stated feeling calmer at the coast than in urban environments. Nonetheless, coastal tourism appears to weaken or even reverse the effect of emotional restoration. This issue is referred to in the study by Bell et al. (2015); however, it remains understudied in the current literature. Further research is definitely needed to assess the impact of tourism on the restorative qualities of the coast.

Awe

The second theme that emerged throughout the interviews was the emotion of awe experienced at the coast. Participants described sensations and perceptions that are compatible with the definition of awe given by Keltner and Haidt (2003). The coast is perceived as larger than one's self, which leads to a need for accommodation in some participants. The power and the grandeur of the sea appear to particularly trigger this perception, but other coastal elements such as the cyclic dynamic of the waves or the mystery beyond the horizon also seem to generate awe. In the study of Pearce et al. (2017), elements that were found to inspire awe at the Australian coast, such as its aesthetic beauty, tidal fluctuations, and vast landscape, were also reported by our participants for the Belgian coast.

Participants who described being unable to comprehend these awe-inspiring phenomena experienced a more negative type of awe with feelings of fear and anxiety. The valence of awe was indeed expressed dimensionally in our interviews and ranged from a fascination toward the power of the sea to unrest or fear toward the potential danger or mystery of the sea. Awe was therefore linked with both positive and negative affect, supporting the notion that it is an ambivalent emotion (Moss and Wilson, 2015). One of our participants demonstrated that frequently interacting with the sea allowed him to be less scared of it. Negatively valenced awe could thus transform into a positive fascination if one were to be more knowledgeable and familiar with the sea, allowing to successfully fulfill one's need for accommodation.

An alternative concept that can be linked to these feelings of fear is the experience of the sublime. According to the philosopher Burke (1757/1990), this emotion is triggered by aesthetic stimuli that convey both power and obscurity, thereby inducing elements of threat and fear. Awe and the sublime are viewed as closely related, with studies suggesting that the sublime can be conceptualized as a threat-based variant of awe (Gordon et al., 2017; Arcangeli et al., 2020). However, recent studies call into question the importance of the fear component in the sublime, with one study demonstrating that awe and the sublime are associated through the dimensions of small self and connectedness instead (Clewis et al., 2021). Further research is needed to clarify the relationship between the sublime and awe and the extent to which the sublime can be linked with experiencing fear at the coast.

Other characteristics of awe appeared in our interviews and can be linked to the facets of awe in the Awe Experience Scale (AWE-S; Yaden et al., 2019). One of these facets is self-diminishment, which refers to the feeling of a small self, and was conveyed by one of our participants, Arne. Self-diminishment has been found to mediate the effect of awe on prosocial behavior (Piff et al., 2015) and humility (Stellar et al., 2018). Our study is consistent with these findings as Arne described feelings of small self that leads him to feel humble toward both nature and other people. Another facet of awe from the AWE-S that was described by our participants was the physical sensations accompanying the experience of awe, such as the "shiver down your spine" described by Victor. Moreover, one aspect of awe that is not included in the AWE-S, but that was expressed by Arne, is the fascination toward the science behind the sea. Studies have indeed shown that awe is positively associated with scientific thinking, to help fulfill the need for accommodation (Valdesolo et al., 2017; Gottlieb et al., 2018). Overall, the experience of awe at the coast reported by our participants is in line with previous studies demonstrating nature, and more specifically the coast, as an elicitor of awe (Shiota et al., 2007; Anderson et al., 2018; Ballew and Omoto, 2018).

Nostalgia

The third theme identified in the interviews refers to the experience of nostalgia at the coast. This experience is characterized by the coast evoking important memories that were created there throughout participants' lives. The qualitative study of Jarratt and Gammon (2016) presents similar findings as their participants described a nostalgic connection with the coast, primarily through the recollection of childhood memories. It is interesting to note the similarity between the present study and the one of Jarratt and Gammon (2016), considering the age difference (their participants were aged between 55 and 74 years old). This similarity is however in line with previous findings showing that proneness to nostalgia follows a curvilinear trend, namely that it peaks in younger (under 30) and older (over 75) adulthood, (Hepper et al., 2021). This is possibly due to the importance of nostalgia in times of transition (Sedikides et al., 2015), such as transition to university or employment. Nostalgia was stated as a reason to visit the coast in Jarratt and Gammon (2016), much like for our own participants, which leads to the hypothesis that the coast facilitates coping with life transitions through the experience of nostalgia. Further research comparing the effect of the coast on different age groups is needed to test this hypothesis.

Just like with awe, the experience of nostalgia at the coast was sometimes expressed more ambivalently. More recent studies demonstrate that nostalgia is an ambivalent, but predominantly positive, emotion (Wildschut et al., 2006; Sedikides and Wildschut, 2016). Although most of our participants indicated feeling positive affect while recalling memories of the coast, other participants expressed a feeling of loss. This feeling of loss is what differentiates nostalgia from mere reminiscence, which is solely a positive form of recollection (Jarratt and Gammon, 2016).

The noted ambivalence in awe and nostalgia could potentially explain their positive influence on well-being. Indeed, studies have found that ambivalent emotions are more likely to support the fulfillment of psychological needs such as the need for autonomy and relatedness (Moss and Wilson, 2015) and to boost adaptive coping styles and resilience to stress (Braniecka et al., 2014). These findings are based on the coactivation model of Larsen et al. (2003) which stipulates that "taking the good with the bad" enables a person to confront adversity and to transform it into an advantage by engaging with the stressor and making meaning out of it. The bittersweet memory recounted by Anna could very well be an example of this very coping process. The present study therefore puts forward the hypothesis that the coast generates experiences of awe and nostalgia, which in turn enable coping with various life stressors, and ultimately benefit well-being.

Taking a look at the content of participants' memories evoked by the coast is important to further understand this experience of nostalgia. Most of the memories were centered around a social context, which is consistent with studies portraying nostalgic narratives as often involving social interactions (Wildschut et al., 2006). Nostalgia has also been found to feature momentous events (Wildschut et al., 2006), such as the memory of swimming in the sea during a storm, described by Noa. Interestingly, other elements in nostalgic memories that are not prominently found in the literature were described in our interviews. These elements reflected for example different seasons at the coast (wintertime and summertime) and their associated natural phenomena, as well as simple daily routines at the beach. Therefore, beyond providing the opportunity to create important social memories, the coast can also elicit nostalgia through symbolic interactions with its natural elements.

Emotion Regulating Strategies

The fourth theme present in the interviews we conducted relates to emotion regulating strategies. Emotion regulation has been defined as "processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (Gross, 1998, p. 275). Several emotion regulating strategies that are considered as adaptive have been described by our participants in relation to the coast. Although emotion regulation has been found to be positively associated with nature and to predict nature's restorative outcomes (Johnsen, 2013), to the best of our knowledge, no studies have specifically evaluated emotion regulation in the context of coastal environments.

A first emotion regulating strategy refers to reflecting on life, problems, and emotions while being at the coast. Reflection has been suggested to contribute to active problem-solving and thereby lead to long-term positive outcomes (Arditte and Joormann, 2011). A previous study already found that exposure to nature increases the ability to reflect on a life problem (Mayer et al., 2009). A second strategy, or "family of strategies," involves meaning-making processes such as acceptance and positive reappraisal, for which numerous psychological benefits have been found (Hayes et al., 1999; Gross and John, 2003). For example, reflection led some participants to be able to accept difficult situations or events, such as Arne accepting the possible "mistakes" he made, often in the context of his autism spectrum disorder (ASD). Other participants displayed positive reappraisal by putting things in perspective, namely to release the stress associated with things considered more trivial. These types of meaning-making processes could be partly due to the experience of awe and nostalgia triggered by the coast, as awe is associated with more focus on the "bigger picture" and nostalgia is linked with redemptive narratives (Wildschut et al., 2006; Piff et al., 2015). A third emotion regulating strategy refers to participants being able to let go or exteriorize emotions while being at the coast. Participants described being able to get a breath of fresh air, clear their mind, and let go of certain thoughts and emotions. This coincided with a deeper awareness of the present moment, and of feeling more connected to one's surroundings. Other participants expressed using the coast for emotional exteriorization that ultimately enables them to calm down and have enough energy to move forward. This can be viewed as the opposite of suppression of emotional expression, which is considered as a risk factor for psychological distress (John and Gross, 2004).

If we take a closer look into these emotion regulating strategies, we notice that some of them resemble components of mindfulness. Mindfulness is considered as the nonjudgmental acceptance of thoughts, feelings, and sensations, while keeping a centered awareness of the present moment (Kabat-Zinn, 1990). This is

in line with the strategies of acceptance and letting go described by the participants. We are therefore led to the hypothesis that the coast triggers emotional and cognitive processes that facilitate the practice of mindfulness, which could further enhance the benefits of well-being at the coast. Indeed, a study by Nisbet et al. (2019) demonstrates that practicing mindfulness while walking along a canal led to stronger connectedness to nature and reduced negative affect, compared to walking along the same path without mindfulness or walking indoors. Their exploratory analyses also revealed that mindfulness led to a higher experience of awe. Future research should therefore aim to replicate this effect for coastal environments.

The final subtheme identified within emotion regulating strategies involves seeking experiences of peak flow. Although emotion regulation and peak flow are independent constructs, it can be argued that they are positively interrelated (Tavares and Freire, 2016). Experiences of peak flow, typically arising during physical activity, are characterized by a feeling of intense satisfaction, that occurs when a person considers their level of skill as sufficient to meet the perceived challenges of that activity (Pomfret and Bramwell, 2016). An example of such an experience was described by Noa; these experiences have been previously reported to take place at the coast (Bell et al., 2015). In addition to triggering peak flow, the coast also appears to facilitate positive stimulation without directly overwhelming our participants with high sensitivity. A study by Caddick et al. (2015) displays similar findings as it explored the effect of surfing on the well-being of combat veterans experiencing posttraumatic stress disorder (PTSD). Their participants expressed that the sensory experience of surfing at the coast enables them to escape from their usual ruminative thinking that typically overwhelms them. It would be beneficial to conduct further research into the benefits of peak flow experiences and positive stimulation at the coast for individuals with mental health disorders such as ASD or PTSD.

Coast as a Safe Haven

The fifth and final theme that emerged from the interviews was the coast as a safe haven. The theme essentially demonstrates that for all participants, the coast represents a safe place where they can feel emotional and vulnerable and have respite from the stressors and pressures of daily life. Participants even described a certain ability to disconnect from reality, by becoming lost in their thoughts. This strongly reflects the concept of "being away" within the attention restoration theory, defined by psychological distance from one's usual thoughts and concerns that require directed attention (Kaplan and Kaplan, 1989). There therefore seems to be a shift in the content and the type of processing of thoughts, with the coast enabling more "reverie," or in other words more unconscious musings over one's life for example (Jarratt and Gammon, 2016).

In relation to this, Noa described a sense of timelessness at the coast, which has been previously linked to the experience of nostalgia, due to the contrast between the permanence of the coast and the fast-paced modern world (Jarratt and Gammon, 2016; Jarratt and Sharpley, 2017). The study of Rudd et al. (2012) demonstrates that the emotion of awe is also found to be associated with an impression of timelessness, as awe increased perceived time availability, which subsequently led to greater life satisfaction. The coast therefore perhaps expands the perception of time through the experience of awe and nostalgia, thereby potentially counteracting "time famine." Time famine refers to the feeling of having too much to do and not enough time to do it (Perlow, 1999). Investigating this mechanism would be beneficial considering that time famine has been shown to have negative health effects, and is possibly associated with burnout (Lehto, 1998; see also Bell et al., 2017).

An additional aspect of the coast as a safe haven relates to the sense of freedom that some participants associate with the coast. Indeed, the COVID-19 pandemic appeared to strengthen this sense of freedom by providing an accessible open-space with a diverse landscape. This is consistent with findings of a positive relationship between access to the coast and well-being during the first-wave lockdown in Belgium (Severin et al., 2021).

To understand why the coast represents a safe haven for our participants, we can link this to the representation of the coast as "home." This representation was also demonstrated by Jellard and Bell (2021), who stated that the coast could be considered as a "home away from home" (Gardner, 2011), enabling a feeling of ease, stability, and connectivity with others who share that same space. Moreover, our participants' representation of the coast strongly reflects the notions of place attachment (i.e., the emotional bond to a place) and place identity (i.e., the cognitive identification to a place; Jorgensen and Stedman, 2001). Place attachment has been linked to numerous psychological benefits, as well as the emotion of nostalgia (Scannell and Gifford, 2017). Additionally, Korpela (1989) argues that place identity is partly formed by processes of emotion- and self-regulation. For example, the ability to reflect in one's favorite place can help maintain one's sense of coherence and self-esteem, which, in turn, can enable the place to have restorative qualities (Korpela and Hartig, 1996). Further research should aim to assess to what extent attachment or familiarity with the coast generates this representation of safe haven and/or whether there are other mechanisms at play.

One example of such a mechanism could be the opportunity to be alone. Most urban cities in Belgium do not have natural spaces that offer the same level of openness such as the coast. In exception to during summertime, the vastness of the coast therefore allows one to be alone, or to the very least, feel alone. Being alone at the coast was appreciated by most of the participants and appeared to facilitate emotional restoration and emotion regulating strategies. The limited presence of other people most likely enables participants to focus their attention to their natural surroundings and/or to themselves.

Limitations, Future Directions, and Implications

The present study was conducted with the use of the well-validated approach of interpretative phenomenological analysis, that enabled us to explore the lived emotional experience generated at the coast for coastal residents. There are nonetheless certain limitations

present in the study. The first limitation arises from implementing the interviews *via* videoconferencing and not physically face to face. This sometimes led to technical hiccups, which possibly formed miscommunications. Additionally, videoconferencing created a different interview atmosphere, in which, on the one hand, some participants potentially had more difficulty opening up and building a relationship of trust with the interviewer. On the other hand, for other participants, this may have facilitated vulnerable exposure due to the psychological distance created by an online interview (Roesler, 2017).

Furthermore, in exception to Noa, our sample consisted of participants that were students or were permanently employed, indicating a minimum amount of socioeconomic stability. Although our participants expressed a number of stressors in their lives, it would be interesting to analyze how groups that undergo a higher degree of stress, such as patients in a rehabilitation center, or individuals with a lower socioeconomic status, experience their emotions at the coast. Although the association between coastal proximity and mental health is shown to be stronger for those with low household income (Garrett et al., 2019), the mediating role of emotional factors for this group remains unknown. Nonetheless, two of our participants are highly sensitive, with one of them having autism spectrum disorder. Recruiting participants with these characteristics was not intended but their experiences helped bring more insight to our analysis, in terms of the function of the coast in emotionally coping with such characteristics.

An important element that should also be taken into account is the contextual influence of the COVID-19 pandemic. During the time period of the interviews, Belgium was experiencing an intense second-wave of COVID-19 infections, along with a number of governmental measures such as closing of nonessential stores and restaurants, a curfew, and restricted social contacts. This second-wave seemed to particularly affect young adults as a series of health surveys demonstrated a rise in anxiety, depression, and dissatisfaction with life for those aged between 18 and 24 years old, compared to the first-wave of COVID-19 infections (Berete et al., 2020). The interpretation of our findings is therefore dependent on this context. For example, several participants expressed the negative impact of the pandemic on their daily routines, vacation jobs, and social interactions. In parallel, participants reported frequently visiting the coast during the lockdown. Considering the overall impact of the pandemic on mental health, it is possible that the prominence of engaging in emotion regulation at the coast was enhanced during this particular time period. Additionally, the pandemic enabled more opportunities to be alone, which perhaps reinforced the notion of the coast as a safe haven.

Finally, our findings cannot be generalized to the general population due to the qualitative focus on the subjective experience of our sample of young coastal residents. Nonetheless, our findings represent various hypotheses that should be tested with quantitative methods, such as the elicitation of awe and nostalgia and the use of adaptive emotion regulating strategies at the coast. The interactions between these different emotional processes should also be further investigated.

In addition to these future directions, several theoretical and practical implications can be taken out from our findings. On a theoretical level, we can hypothesize that, due to their beneficial nature, the stated emotions and related emotion regulating strategies elicited by the coast may play a positive role on the well-being of our participants. This could thus indicate an indirect relationship between the coast and well-being. Moreover, our findings demonstrate that coastal residents can experience similar emotional processes as coastal visitors/tourists, such as the emotions of awe and nostalgia. However, the feeling of safety at the coast is perhaps unique to coastal residents, due to their familiarity with the coast. Our study therefore enriches the literature with a specific look into emotional mechanisms in the relationship between the coast and well-being for coastal residents.

On a practical level, we suggest that we aim to preserve the factors that facilitate the beneficial emotional experiences highlighted in our study. For example, we should promote physical activity at the coast, such as watersports, that enable experiences of peak flow or emotional restoration. We should also promote social interactions but only to a reasonable extent. Based on our interviews, experiencing nostalgia was partly dependent on important social memories created at the coast; however, the opportunity to be alone was also associated with various adaptive emotion regulating strategies. Additionally, mass tourism during the summer has a negative impact on the coast's restorative qualities. Efforts should therefore be made to limit overcrowding, such as optimizing spatial distribution (Basterretxea-Iribar et al., 2019) or instating reservation systems to access the beach. The emotion of awe also depends on natural characteristics such as openness and aesthetic beauty; these elements should therefore be safeguarded, such as by reducing littering at the coast.

Finally, investigating the role of emotional processes triggered by the coast on well-being can bring insight into possible solutions in the prevention of psychological distress and support of mental health. Developing the use of mindfulness at the coast with the elicitation of awe could for example potentially benefit coping with burnout or mood disorders or even other conditions undermining people's well-being. Furthermore, the findings represented in our study could lead to important opportunities for contexts other than mental health. For example, the emotional and restorative experience of the coast could be recalled and utilized to promote training of emotional intelligence. In short, emotional intelligence skills can be divided into four abilities, namely the ability to perceive emotions, to use emotions to facilitate thought, to understand emotions, and to manage emotions (Mayer et al., 2004). Developing these skills has been found to positively affect academic performance, social interactions, and organizational behavior (Mayer et al., 2004). Young adults could particularly benefit from these skills, considering that they experience important transitions within these educational, social, and work contexts (Arnett et al., 2014).

CONCLUSION

The present study demonstrates that young coastal residents can experience complex emotional processes at the coast, namely

the ambivalent emotions of awe and nostalgia, as well as emotional restoration. These emotions appear to be facilitated by the coast's multisensory and symbolic qualities. Furthermore, the coast is featured as a safe place that allows participants to engage in adaptive emotion regulating strategies and to distance themselves from daily life stressors. These findings indicate a potential benefit of these emotional processes on the well-being of our participants. We therefore argue that the emotional mechanisms highlighted in our study should be considered as possible contributors to the coast's therapeutic potential, alongside the putative physical, social, and cognitive mechanisms.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethical Committee of the Faculty of Psychology and Educational Sciences of Ghent University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MS contributed to the conceptualization, methodology, data analysis, and writing of the manuscript. LL and EN wrote their master thesis based on the present study and took part in the conceptualization, methodology, data collection, and data analysis. FR, GE, and AB were involved in conceptualization, supervision, and review and editing of the manuscript. AB also supervised the data analysis. All authors contributed to the article and approved the submitted version.

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Social Workers' Choice Making in Supporting Nature Activities by Parents and Children in Shelters

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Visiting a natural environment such as a garden or park helps people to recover from stressful circumstances. Women's shelters and homeless shelters have started to integrate nature in their work, especially for families who seek temporary refuge, with the aim to support parents' functioning and resilience. For professionals who want to facilitate engagement with nature among their clients, it may be helpful to learn how other professionals choose nature activities for the support of parents. The current study was aimed to uncover how social workers choose a nature activity for the support of parents, resulting in a model that can be used as a reflective tool among shelter professionals. The model is based on an analysis of actions of professionals, captured in case descriptions written by shelter professionals about parenting supportive nature activities that they facilitated for families under their care. The model shows that social workers promoted a back-and-forth between children's exploration away from the parent and being with the parent. In facilitating these interactions, social workers used nature as an environment with stress reducing and strengthening capacities for parents and as an environment with supportive qualities for children's play. A dimensional framework was extracted that described how professionals may choose activities.

Keywords: integrating nature, shelters, recovery, building, secure base phenomenon, nature-based intervention

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INTRODUCTION

When families have no safe or suitable living place and have support needs that cannot be met in their informal network, shelters can provide temporary homes. Homeless shelters focus on people who have no suitable home, for example due to home eviction after financial problems, and women's shelters focus on women who are unsafe due to threat and abuse. Shelters provide physical safety and shelters professionals offer psychological support, arrange work and finances, and help families obtain permanent independent housing, aiming for a return to independent family functioning (Council of Europe, 2011; Lisbon Declaration on the European Platform on Combatting Homelessness, 2021). Notwithstanding these efforts, shelter life can also bring stressors to parental functioning that can impede independent family life. Parents have reported noise and chaos in the

shelter living spaces, imposed shelter rules that do not match with parents' own rules and routines, experiences that reduced self-esteem in their parental role, feelings of distrust toward shelter service provides, challenges to parental mental health, lack of material resources for parenting, and issues with stigma and negative stereotypes of homeless parents, that bring challenges to maintaining parents' wellbeing, household routines and family functioning (Pable, 2012; Glenn and Goodman, 2015; Anthony et al., 2018; Bradley et al., 2018; Sylvestre et al., 2018; Matthews, 2021; Vrabic et al., 2022). It is important that shelter organizations find ways to make shelter experiences beneficial or at least not adverse to parental functioning.

Visiting a natural environment such as a garden, children's farm, a forest, or park can be supportive to families. Studies in shelters as well as in other living places have indicated that natural environments near a family's living place can be used as a safe and engaging place for family activities, where parents can find fun and unconstrained ways to interact with their children (Ashbullby et al., 2013; Izenstark et al., 2016, 2021; Cameron-Faulkner et al., 2018; Millican et al., 2019; Kotozaki, 2020; Rantala and Puhakka, 2020; Peters et al., 2020a; Varning Poulsen et al., 2020). Such positive moments in nature are associated with stress reduction in parents (Razani et al., 2018; Kotozaki, 2020) and responsive interactions between parent and child (Cameron-Faulkner et al., 2018). For parents in shelters specifically, experiences in a natural environment have been associated with parents' experiences of connectedness with their child, autonomy in making parenting decisions, and competence in their parenting practice (Peters et al., 2020a,b, 2021). These findings suggest that professionals may use engagement with nature to support parents in shelters.

Several shelters have integrated nature in their practice to support parents' functioning and resilience (Renzetti et al., 2014; Lygum et al., 2019; Millican et al., 2019; Norton et al., 2020; Peters et al., 2020a,b; Varning Poulsen et al., 2020) such as by offering seasonal celebrations in nature, walk and talk therapy, outdoor adventure experiences, therapeutic horticulture, or outdoor play moments. Thus far, little is known about how professionals choose nature activities for the support of parents. If helping families to engage with nature is to be part of professional skills and training, description and understanding is needed of choices that professionals might implicitly or explicitly make, when determining whether a nature activity may be good for a family.

The current study was aimed to describe the choices that social workers make when they facilitate a nature intervention with the intention to support parents. Professionals' choices can best be constructed on observations of the actual behavior of professionals, so that the choices can be inferred from their actions in practice (Ryle, 2009; Kinsella, 2010; Schön, 2017). To collect data on the actual behavior of professionals, case descriptions with detailed descriptions of actual actions of the professional and the behavior of their client can be informative (Argyris and Schon, 1974). In this study, we collected and analyzed case descriptions that shelter professionals wrote about parenting supportive nature activities that they facilitated for families under their care.

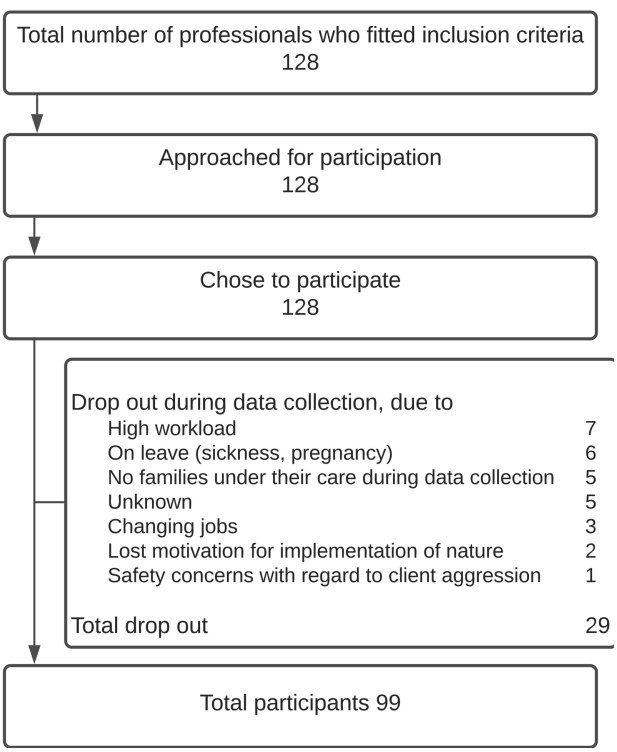
MATERIALS AND METHODS

Participants

This study included 99 shelter professionals who worked in child and family social work in a shelter for homeless families or in women's shelters in the Netherlands during the study period (October 2018 until February 2019). The shelter professionals were selected from 20 shelters that participated in a Dutch nationwide project aimed to enhance the wellbeing of families in shelters through the development and use of natural environments. One year prior to data collection, each shelter had received funding for the design and landscaping of natural places. Each shelter developed a restorative garden, a natural play area, a children's farm, and/or a vegetable garden.

Shelter managers were asked to include team members for participation in this study on the basis of being a professionally educated child and family social worker, being motivated to use nature in shelter social work, and being motivated to participate in research. Shelter managers provided the researchers with a list of team members who fitted the inclusion criteria, after which researchers contacted the professionals to inform them about the goal of the study and their rights as participants. Participating professionals signed for informed consent. For the participant flow, see **Table 1**.

TABLE 1 | Participant flow.



All participating professionals were educated in child and family social work in secondary vocational training, bachelor education, or master education. Their training includes assessing the needs of their clients by listening, questioning, observing, and professionally weighing these sources of information to form a professional judgment, as well as in facilitating activities in the support of their clients, and in critically reflecting on the effects. For participant characteristics, see **Table 2**. Professionals participated during their regular and paid working hours. Shelters could claim the expenses for professionals' time spent on participation in the research, with a maximum of 32 h per professional at their hourly rate.

All participating professionals took four training sessions in which they shared ideas for and experiences with nature activities for families under their care and reflected on their practice in conversations with colleagues, with the aim to develop, maintain, and share professional insights on nature activities for parents in shelters. After the second and third training session, data collection took place.

Nature Activity Case Descriptions

Professionals facilitated a nature activity for a family under their care, either on the shelter property or in natural environments near the shelter. Nature activities were offered according to the family's possibilities, preferences, and needs. Immediately after the nature activity, professionals wrote a case description with the date and time, the name of the shelter, a written observation of the parent's parental needs based on the question "What needs did the parent have at this moment (based on your professional judgment)?", a written description of the nature activity based on the question: "You facilitated a nature activity. What exactly happened? Describe the activity," and a written observation based on the questions: "What did you notice in the parent? And what else? And what else?". Parents filled out an online questionnaire about their parental need satisfaction and need frustration and their connectedness to nature, of which the results have been published (Peters et al., 2020b).

The Scientific and Ethical Review Board of the Faculty of Behavioral and Movement Sciences of the VU Amsterdam approved of the study protocol (VCWE-2018-0138).

TABLE 2 | Participant characteristics.

Gender	92 female, 7 male
Position	62 social worker/case manager/personal coach (educated in BA-education) 32 group worker/child and youth worker (educated in vocational education) 4 child and family counselor (educational level unknown) 1 family therapist (educated in MA-education)
Type of shelter	13 women's shelter 5 shelters for homeless families 2 combined women's shelter/ shelter for homeless families

Analyses

Data consisted of 160 case descriptions. Eleven cases were removed because they had missing data or because the case described no nature activity with a family (for example, cases that described a professional with a child during a nature activity, without its parents). This resulted in a total of 149 cases for analysis. The data was thematically analysed using Atlas.ti 9.0.5 for Mac, using a Grounded Theory approach (Glaser and Strauss, 2017). The analysis was aimed to identify professional decisions in choosing nature activities for families in shelters One researcher conducted the analyses, supported by two researchers who parallel coded parts of the data. Researchers discussed the codes and importance of the codes until consensus was obtained. Memoing was used throughout the process of analysis. The analysis followed six steps:

Open Coding

A principal analyst used the *in vivo* coding setting to explore and code the content, aiming for a set of codes that represented each case. A peer analysts coded portions of these same data, after which the three analysts jointly discussed the codes and importance of the codes until consensus was obtained.

Axial Coding

The principal analyst and two peer analysts jointly analysed an initial set of 50 cases by comparing data within codes to explore patterns and exceptions in the data regarding that particular code. We asked ourselves what central themes could be used to describe these cases, resulting in concepts. All cases were subsequently analyzed by the principal analyst by asking if each case could be properly represented using the initial concepts, to identify if other concepts were needed, or if existing codes should be made better applicable. During coding, constant comparison was used to repeatedly check ideas against data in order to avoid confirmation bias (Boeije, 2002). This cycle of coding and comparing continued in an iterative, non-linear fashion until saturation was reached.

Selective Coding

By exploring connections and through further combining and summarizing, the principal analyst extracted core components and presented and discussed these with the peer analysts.

Negative Cases Analysis

The principal analyst marked aspects of the data that were in contrast with the apparent patterns in the data as negative cases. She refined and broadened her analysis until the codes covered almost all cases, which required the analyst to expand and revise her interpretation until a maximum number of cases could be explained, including those that were initially marked as negative cases or "outliers." Any cases that did not fit the final model were documented in the final report to allow re-evaluation by others (Onwuegbuzie and Leech, 2007; Anney, 2014).

Network

The principal analyst worked to identify structures in the data set by linking codes, creating hierarchy, and visualizing the codes in a network. This process formed a model that described the choices that professionals made in facilitating nature activities for the support of parents in shelters. The model was presented to the two peer analysts as well as to all co-authors, supported by quotes from the original data set, for questioning and discussion.

Validation of the Results

To control the interpretations and consistency in meaning making the results were presented to a focus group of six participating professionals. We used peer debriefing by discussing the results of the study to a group of four researchers in the field of environmental psychology. The principal analyst who conducted the analyses took an academic course on grounded theory to improve reflexivity. In this article we illustrated the findings with raw data to present findings within their context.

RESULTS

Descriptives

Case descriptions portrayed nature activities with parents (age $M = 31.95$, SD = 6.79) and their children (age $M = 5.2$, SD = 3.69). Nature activities were conducted with one child ($n = 97$), two children ($n = 34$), three children ($n = 10$), four children ($n = 3$), or five children ($n = 3$) and one parent ($n = 143$) or two parents ($n = 4$; missing data $n = 2$).

Professional Decision in Choosing Nature Activities

The process of axial coding resulted in a series of codes. **Supplementary Material 1** shows the codes and the number of occurrences of each code. The codes from axial coding were summarized and combined, resulting in three major themes.

Theme 1: Choosing Practical Dimensions When Facilitating Nature Activities

This theme includes eight dimensions according to which professionals chose a position when facilitating a nature activity for a family.

1. Physical Activity: professionals chose between a more sedentary and more physically active activity.
2. Familiarity: professionals chose between a more well-known and a newer experience.
3. Nature Interaction: professional chose between looking at nature and interacting with nature.
4. Proximity: professionals chose between staying close to and going further away from the shelter.
5. Location: professionals chose between a nature activity in an indoor space and a nature activity in an outdoor space.
6. Predictability: professionals chose between working with more predictable elements of nature and more unpredictable elements of nature.
7. Autonomy: professionals chose between an activity that was largely supported by the professional and more autonomous family time.
8. Openness of the Assignment: professionals chose between an activity with a more directive assignment and with a more open (or no) assignment.

Supplementary Material 2 provides illustrative quotes for every dimension.

In choosing the practical dimensions, professionals made personalized choices for each family. As an example, when professionals aimed the nature activity to help a mother in making contact with her child, one professional chose for a directive assignment (Quote respondent 1131: "The mother is holding back and insecure in making contact with daughter. The frame of the assignment helps her to show engagement"), while another professional chose for an open assignment (Quote respondent 1471: "The mother gets enthusiastic from everything she sees. Some things trigger memories, like blowing on a whistle from an acorn hat that we found on the ground. But she also talks about everything you can find in the wood to use. Her son seems focused on mom: he listens and is interested in everything. In mother I see serenity, relaxation, diversion. Other emotions. Focus on her child").

Theme 2: Choosing to Use Opportunities of Nature to Facilitate a Specific Experience

This theme identifies opportunities of nature that professionals used to facilitate a specific experience, namely nature's opportunities for children to explore, nature's opportunities for stress reduction for parents, and nature's strengthening opportunities for parents.

Exploration opportunities were related to free play, as is illustrated in this example (Quote respondent 0741: "I see a child who wants to explore and the imagination that she shows; for example, putting the leaves she collected in her coat pocket, trading leaves with others, putting the leaves inside the toys she brought to see if they came out"). Professionals mentioned nature as an interesting play environment (Quote respondent 1551: "Both the playground and simply a frozen puddle of water provide a challenge to do something for and with the children"), they mentioned children's freedom in play behavior (Quote respondent 1151: "The children were excited, entered the bushes and shrubs without hesitation, searched under and on top, got dirty and laughed about it"), and they mentioned children's involvement in play (Quote respondent 1561: "Both the children play, have attention, have fun. Mother enjoys it. Children have their focus, playing is their activity in that moment").

Stress reducing opportunities for a parent were related to recovering from stressors, often indicated by feelings of relaxation, escaping daily stressors, and reducing feelings of anxiety and worries, as is illustrated in this example: (Quote respondent 1641: "Mother looks relaxed and lets the children do their own thing in the woods. They are free to run and walk and play with the dog. Mother says she finds it calming to be outside in nature. I get the impression she feels at ease there").

Strengthening opportunities for a parent were related to positive experiences, creating social bonds, connecting to the family's past, and building (new) family routines, as is illustrated in this example: [Quote respondent 1511: "Because they both love animals and the petting zoo was just around the corner of their home, they used to go there often. While here, they have not been there ever, not for the past 7 months. I went to the petting zoo together with mother and daughter (…). Because they liked it so much and they enjoyed the animals and the fresh air so much, mother wants to do this more often. It is their moment together; in this way they share their love for animals"].

Theme 3: Choosing to Facilitate a Specific Pattern of Interaction Between Parent and Child

This theme identifies the pattern of interaction that professionals facilitated between parent and child during the nature activity. Professionals facilitated a pattern in which children switched between exploring away from the parent and seeking proximity to the parent. While children explored, parents functioned as a secure base by being available, responsive to the child's needs, and providing effective comfort.

Children exploring away from the parents is illustrated in this example: [Quote respondent 0191: "The children immediately ran around in the outdoor playground. The oldest (boy) jumped on the swing in the shape of a nest, the three middle ones (girls) climbed on the playset and the youngest immediately spotted the chalk"], and children seeking proximity to the parent is illustrated in this example: (Quote respondent 0771: "They love feeding the animals. Always asking for confirmation whether mother sees them when they give bread to one of the animals. Mother reacts positively"). Parents' secure base behavior is shown in this example: [Quote respondent 1441: "When daughter comes over with a sad face (fallen) this changes by a single question from mother. Mother listens to what happened, and daughter soon says it's better already"].

The pattern of children's exploration and return while parents functioned as a secure base was present in almost all cases. This pattern of interaction was not always positive. In some cases, parents were not available (Quote respondent 0671: "Now and again the child sought out his mother to show what he had discovered or get her attention. Mother did not always know how to react, looked unsure of herself"), or restricted the child's exploration [Quote respondent 1571: "Daughter often indicated she wanted to walk on her own, while mother was trying to hold her by the hand. (…) Mother felt the need to keep her daughter close to her. She seemed eager to control this. When I asked about it, she said this was correct, that she finds it difficult to let her daughter explore out there"].

Negative Case Analysis

Two cases were in contrast with the rest of the data and were identified as negative cases. In these cases, professionals aimed for a different pattern for interaction between parent and child compared to the rest of the cases in the data set. Both negative cases described an activity in which professionals gave strict behavioral instructions to both parents and children with the intention to practice a new skill (psycho-physical resilience in one case, collaborative skills in the other case). In these cases, professionals left limited degrees of freedom to the child's exploration. In the rest of the data professionals may also have described assignments and directions for behavior in parents in children, but still left room for initiatives from the parent or the child which allowed them to balance between proximity seeking and exploration.

Network

We made a network of codes to identify structures in the data set, with the aim to understand professionals' choices when facilitating nature activities for the support of parents. The model presented in **Figure 1** describes professionals' choices as immerged from the data.

Validation

For validation, results were discussed in a focus group with six professionals who had participated in the study, and with four researchers in the field of environmental psychology. The professionals recognized that they used nature as a setting with stress reducing and strengthening capacities for parents and exploration opportunities for children, and that they made choices on the eight dimensions to make the nature activity fitting for a specific family (Quote respondent 103: "I do indeed recognize that our social workers consciously think about relaxation moments for parents and play opportunities for children. As a team, we certainly think that nature is helpful in this"). All professionals in the focus group recognized that they chose activities that promoted a back-and-forth between children's exploration away from the parent and return. Some professionals recognized their own role in this (Quote respondent 101: "I do try to sometimes involve a parent in the child's activities: proximity; and sometimes stimulate a parent to let a child do something independently: distance. Sometimes you give some guidance, sometimes you just let things happen between parent and child"). Other professionals saw it as a side effect (Quote respondent 103: "I think that our family social workers are to a lesser extent consciously engaged in creating a balance in distance and proximity, but rather experience that this is a favorable side effect of working with nature," Quote respondent 104: "At present the issue of distance/proximity and mutual contact between parent and child remains consciously observed by our colleagues but is not yet really pursued on purpose. It just happens, outside"). The professionals and the psychological researchers stressed that the choices for practical dimensions of the nature activities were partly influenced by practical considerations (Quote respondent 101: "But practical considerations, for example close to the shelter, free of charge, *etcetera*, are also decisive for the choice of activity") and that decisions were not always planned prior to the activity but partially made in response to what happened during the activity.

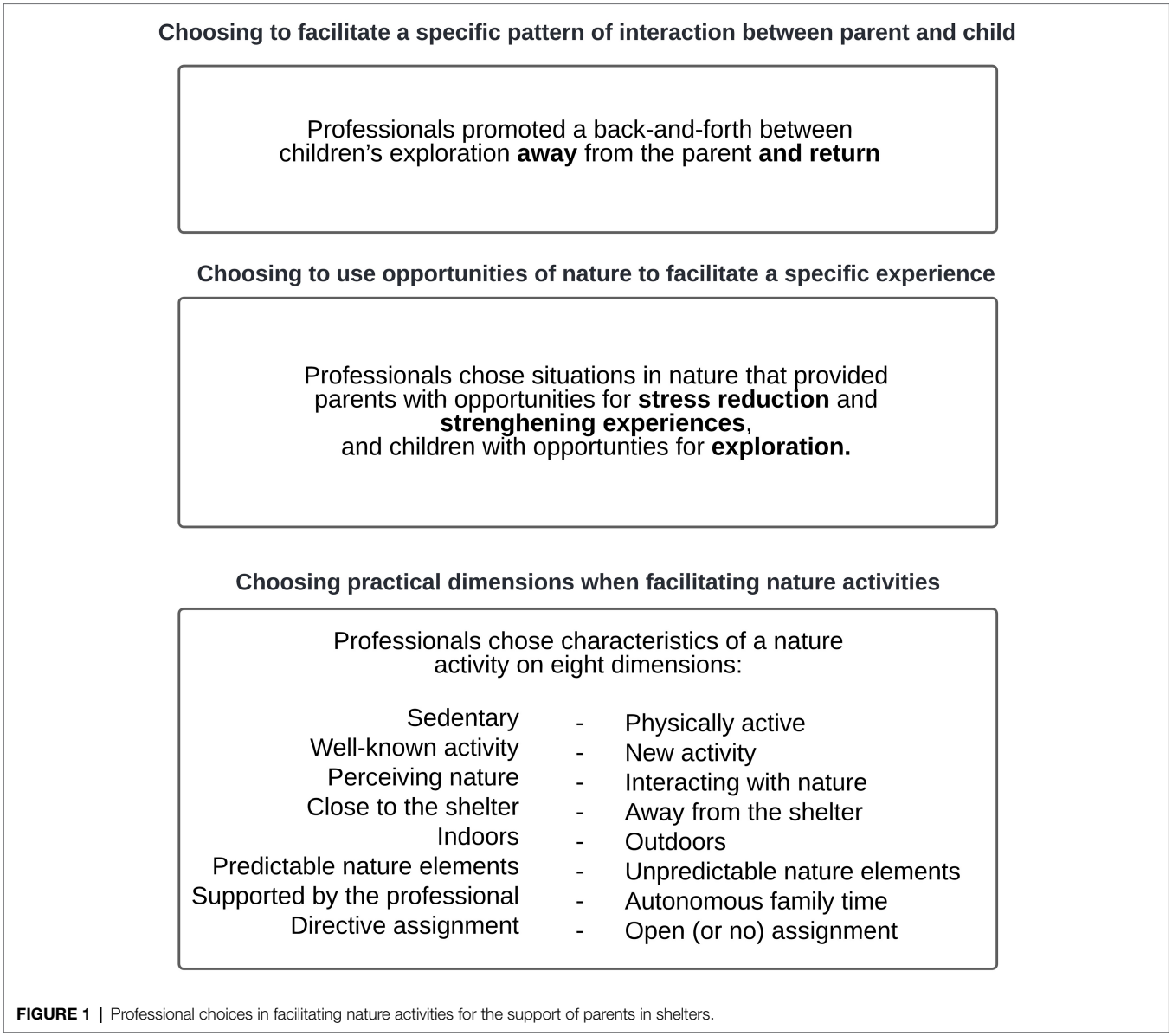


FIGURE 1 | Professional choices in facilitating nature activities for the support of parents in shelters.

DISCUSSION

With this study we aim to uncover shelter professionals' choices when facilitating nature activities for the support of parents. In the current discussion we connect the results of the analysis to literature to demonstrate how the study results relate to extant knowledge within the field, using the jargon from the field (Stern, 2007).

Linking Findings to Extant Literature

When facilitating nature activities for the support of parents in shelters, professionals chose to facilitate nature activities that promoted a back-and-forth between children's exploration away from the parent, and return. These interactions followed the pattern of Secure Base Phenomenon (Ainsworth, 1967; Posada et al., 2013). Professionals facilitated such interactions, and only by exception opted for a different pattern for interaction (the "negative cases" in the Results). Other patterns may have occurred if professionals made different choices in the design of nature activities, for example by choosing activities that left little room for exploration, or by choosing activities in which parents could not be available for the child such as activities that caused high levels of arousal, or activities that required directed attention on something else than the child. Social workers' primary focus on creating interactions according to secure base phenomenon is in line with a recent finding that child care professionals rely on Attachment Theory most often for their child supportive work (Department of Education, 2018).

In facilitating secure base interactions, professionals used nature's capacities for supporting children's exploration, and nature's capacities for facilitating stress reduction and strengthening experiences. Regarding children's exploration,

professionals chose activities in which nature functioned as an interesting play environment that allowed children's freedom in play behavior and stimulated their involvement in play activities. Theories on play suggest that natural environments can function as a setting for rich explorations (Nicholson, 1972; Heft, 1988). Natural environments are described as a setting that fits with children's needs and desires for exploration and play (Spencer et al., 2019), where children play long, involved and diverse (Luchs and Fikus, 2013; Zamani and Moore, 2013). Professionals' choices revealed that they set the scene for secure base behavior by choosing the environment so that it offered exploration opportunities for the child.

Regarding parents' stress reduction and strengthening experiences, professionals chose activities in which nature offered opportunities for restoring energy, reducing feelings of anxiety, and experiencing positive interactions. Experts in the field of environmental studies have also described these capabilities of nature with the terms restoration and building (Markevych et al., 2017), with restoration referring to the ability of nature to restore resources that have been depleted in efforts to cope with stressors, and building referring to the deepening or strengthening of capabilities for meeting everyday demands (Marselle et al., 2021). Several theories were aimed to explain why natural environments can be experienced as non-threatening and stress reducing (Wilson, 1984; Kaplan and Kaplan, 1989; Ulrich et al., 1991; Kaplan, 1995; Kuo, 2015). Interestingly, recovery from stressors can been linked to higher psychological availability of parents, and more autonomy supportive and less controlling parenting behavior (Van Der Kaap-Deeder et al., 2019; Robichaud et al., 2020). Professionals' choices revealed that professionals set the scene for secure base behavior by choosing the environment so that it facilitates parents to be available to their child and supportive of the child's autonomy.

To facilitate exploration in children and stress reduction and strengthening experiences in parents, professionals made practical choices on eight dimensions. Professionals made unique choices on these dimensions for each family. According to Theory of Affordances (Gibson, 2014) every physical setting has unique properties for every individual. This means that, when aiming to facilitate certain behavior through engagement with an environment, one must consider the physical aspects of the environment as well as the characteristics of the family. Professionals' choices show that they selected unique characteristics of a place to make its affordances fitting for a family.

Notes for Interpretation

Professionals chose to facilitate interactions according to secure base phenomenon in their nature activities. This does not mean that we expect nature activities to be uniquely suitable for secure base interactions, nor that we expect professionals to use their knowledge on secure base phenomenon only during activities in nature. It may equally well be expected that professionals facilitate possibilities for secure base interactions on other moments in their professional practice, such as during indoor play moments or dinner time. This research shows that professionals also included secure base knowledge in their choices for facilitating nature activities.

The current study uncovers professionals integrated knowledge that is compatible with attachment theory in their choices for nature activities. Professionals might have well used other knowledge aspects, such as knowledge on physical fitness (which could have shown if professionals chose activities focused on building physical strength or getting vitamin D), or knowledge on social connectedness (which could have shown if professionals chose activities focused on connecting to the neighborhood or building friendships), or knowledge on self-connectedness (which could have shown if professional chose activities such as forest bathing, mindfulness, or yoga). It is of interest that professionals chose a social interaction perspective because it adds a new perspective to existing literature that has mainly focused on nature activities for physical health and mental wellbeing (Van den Bosch and Sang, 2017; Twohig-Bennett and Jones, 2018; Bratman et al., 2019; Lackey et al., 2021).

As professionals in the focus group highlighted, some aspects of the activity 'occurred' without professionals' intentional guidance. Each activity reflected input from the professional, the parent, the child, and characteristics of the natural environment, that all interacted with each other, which makes the activity not only a result of the choices of professionals. The professional choices that were the focus of this study referred therefore to the input that professionals chose to provide in the decision process with the family about the nature activity.

Strengths and Limitations

The study was conducted in the setting of a shelter, during regular working practice, with regular clients. This contributed to the ecological validity of the study findings. The study was conducted among a selected group of professionals. All professionals were educated in child and family social work, were selected by their team manager, worked in a shelter that had implemented nature to enhance the wellbeing of families, and were trained in the implementation of nature for parents. This allowed us to analyze data from professionals who we expected to be skilled and knowledgeable on the subject. Their choices were the basis on which a practice-based model was made.

No professionals dropped out during the informed consent procedure, but 23% of professional participants dropped out during data collection (see **Table 1**). Natural turnover of staff and clients, which is to be expected with a study period of 12 months, explained almost half of the dropout. The remaining dropout was 12%, which is acceptable (Furlan et al., 2009).

The data in this study consisted of case descriptions in which professionals described moments in their own practice. As Ryle (2009) argued, the mind of professionals is revealed in their doings, and explainable by the doers' aims. This makes case descriptions suitable material for analyzing

professional choices. We recognize three limitations in the way we collected case descriptions. Firstly, the case descriptions were limited in richness. Case descriptions were based on a predefined set of questions, which limited the options for rich elaborations by professionals, and limited opportunities for researchers to ask further questions. The written accounts by professionals were a representation of their actions in practice, but a first-hand involvement from the researchers, using their reflective and interpretive stance in interaction with the professionals, could have deepened our understanding. Secondly, professionals' desired behavior, intentions, and world views could have interfered with their descriptions of their actual behavior. Professionals wrote about their own practice, which is already a reflection on their behavior (even though it was written immediately after the nature activity) and not necessarily an actual representation of the behavior itself. Professionals may have filtered their actual actions through the lens of their desired behavior, to make it sensible, logical, and concurrent with their values. A relational approach in data collection with researchers closer to the professionals, e.g., by actively observing professionals in action, could have strengthened the study. Thirdly, data collection and analysis were performed separately, which prevented theoretical sampling (Glaser and Strauss, 2017). Theoretical sampling could have made further examination of the categories and their relationships possible, such as an examination of the conditions under which certain characteristics of nature activities were chosen.

Implications for Practice

This study describes the daily practical choices that professionals make when facilitating a nature intervention for a family in their care with the intention to support parents. The results of the study can be used by professionals who aim to implement nature to support parents in their practice. The results can make professionals aware of the choices that other professionals make. On the one hand, such insight may be interesting for professionals who are beginners in the use of nature activities in their parenting supportive practice. For them, the results can function as a "cheat sheet" on which they can see how more experienced colleagues make their choices, and so inform their own choices for facilitating nature engagement among their clients. On the other hand, the insights from this study may be used by professionals to reflect on practice. The results can function as a 'mirror' that reflects current choices. Such a 'mirror' can stimulate reflective conversation, for example by discussing if the choices reflect what professionals consider good practice. To aid this practical use of the study results, we made a printable poster that can function as a reflective tool for practice (**Supplementary Material 3**).

The data of this study have been collected on shelters that had some form of nature on their own property, safe and open to the families. Shelter professionals who do not have a natural environment at their disposal may be limited in the choices available to them. Especially for clients for whom safety is at risk or who face financial barriers, professionals will be very limited in choosing to go outdoors, to go further away from the shelter, or to facilitate autonomous family time in nature, if no safe and affordable natural environment of their own choice is available. It may well be that a safe garden on the shelter's property is an important prerequisite for being able to make apt professional choices. If professionals are limited in making the choices from the model due to practical constraints, the model cannot function as intended. We invite professionals to make an analysis of the natural environments they have available at work, to determine whether using the model fits to their practice.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Scientific and Ethical Review Board of the Faculty of Behavioral and Movement Sciences of the VU Amsterdam (VCWE-2018-0138). The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

EP, DH, JM, and CS: conceptualization. EP and DH: funding acquisition. EP: data collection and writing—original draft. EP and JM: analysis and interpretation. DH, JM, and CS: supervision and writing—review and editing. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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The Need for Sustainability, Equity, and International Exchange: Perspectives of Early Career Environmental Psychologists on the Future of Conferences

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At the 2019 and 2021 International Conference on Environmental Psychology, discussions were held on the future of conferences in light of the enormous greenhouse gas emissions and inequities associated with conference travel. In this manuscript, we provide an early career researcher (ECR) perspective on this discussion. We argue that travel-intensive conference practices damage both the environment and our credibility as a discipline, conflict with the intrinsic values and motivations of our discipline, and are inequitable. As such, they must change. This change can be achieved by moving toward virtual and hybrid conferences, which can reduce researchers' carbon footprints and promote equity, if employed carefully and with informal exchange as a priority. By acting collectively and with the support of institutional change, we can adapt conference travel norms in our field. To investigate whether our arguments correspond to views in the wider community of ECRs within environmental psychology, we conducted a community case study. By leveraging our professional networks and directly contacting researchers in countries underrepresented in those networks, we recruited 117 ECRs in 32 countries for an online survey in February 2022. The surveyed ECRs supported a change in conference travel practices, including flying less, and perceived the number of researchers wanting to reduce their travel emissions to be growing. Thirteen percent of respondents had even considered leaving academia due to travel requirements. Concerning alternative conference formats, a mixed picture

emerged. Overall, participants had slightly negative evaluations of virtual conferences, but expected them to improve within the next 5 years. However, ECRs with health issues, facing visa challenges, on low funding, living in remote areas, with caretaking obligations or facing travel restrictions due to COVID-19 expected a switch toward virtual or hybrid conferences to positively affect their groups. Participants were divided about their ability to build professional relationships in virtual settings, but believed that maintaining relationships virtually is possible. We conclude by arguing that the concerns of ECRs in environmental psychology about current and alternative conference practices must be taken seriously. We call on our community to work on collective solutions and less travel-intensive conference designs using participatory methods.

Keywords: scientific conferences, early career researcher (ECR), travel-intensive conferences, academic travel, equitable academia, accessibility, inclusivity, sustainable academia

INTRODUCTION

International scientific conferences held in person are unsustainable and inequitable. Attendee travel (among other factors) causes high CO_2 emissions thus contributing to climate change (van Ewijk and Hoekman, 2021). Unsurprisingly, air travel makes up a substantial share of many academic institutions' overall emissions (e.g., 63–73% at the University of British Columbia; Wynes and Donner, 2018), of which conference travel constitutes a substantial share (Achten et al., 2013). Further, the requirement for traveling to conferences systematically excludes disadvantaged researchers [e.g., researchers with disabilities, caretaking responsibilities, early career researchers (ECRs); Sarabipour et al., 2021; Skiles et al., 2021].

In this community case study, we focus on travel-intensive conference practices within the environmental psychology research community. We suggest that, in addition to researching air travel behavior, the community should reduce its own air travel. This change, however, is difficult, as academics often regard air travel as necessary to advance their career (e.g., to network, to disseminate their work; Higham et al., 2019; Nursey-Bray et al., 2019), even though evidence suggests that air travel influences academic career success only limitedly (Wynes et al., 2019).

Against this backdrop, symposia took place at the 2019 and 2021 International Conference on Environmental Psychology (ICEP), during which researchers debated how the environmental psychology community should conduct conferences in the future. Many community members agreed that emissions from conference travel should be reduced. Nevertheless, some cautioned against changing current conference practices, fearing this could undermine the quality of the conference. In this manuscript, we—an international author team of ECRs in environmental psychology—wish to continue this timely debate by contributing an ECRs perspective. We continue to focus on conference travel, as some suggest that conferences are the most common purpose for academic travel (Glover et al., 2019). Conferences also offer an opportunity to alter the behavior of many individuals at once by fostering new community norms.

CONFERENCE PRACTICES IN THE ENVIRONMENTAL PSYCHOLOGY COMMUNITY

Conferences on environmental psychology have served our community by fostering interconnectedness and research collaboration. These conferences have evolved over the years to adapt to changing circumstances and shifting needs of a developing research community (e.g., increased internationalization), and they must continue to adapt in order to address environmental and equity challenges. Some steps in this direction have already been taken. For example, when submitting bids to host ICEP, bidders must provide information on the carbon emissions associated with their proposal (ICEP Organizing Committee, 2019).

As ECRs, we are very grateful for the immense effort that was invested into designing and maintaining conferences like ICEP. Nevertheless, we believe that in light of the emissions and inequities associated with travel-intensive conference practices, it is time to adapt further, not least to accommodate the growing number of community members who want to reduce their travel emissions to limit global warming (Together Science Can, 2019; Matthies et al., 2021) as well as disadvantaged researchers who are currently excluded from conferences. We do not wish to disregard the benefits of current conference travel practices, but to invite the community to look for new approaches, which allow us to make necessary changes without losing the valuable structures we have established.

AIM OF THIS MANUSCRIPT

We aim to continue the discussion about the format of future conferences started at ICEP 2019 and 2021, and to develop it by providing an ECRs perspective. We further aim to provide empirical insights into the views of ECRs in our community regarding travel-intensive conference practices and their visions of possible changes. In doing so, we want to make it easier for those making strategic decisions in our community to consider the viewpoints of ECRs.

We deem it particularly important to present the views of ECRs because their views are currently underrepresented in conference planning (Bankston et al., 2020), despite the prevalent belief that they must travel in order to build a professional network (Higham et al., 2019; Matthies et al., 2021). This gives ECRs a special position within the discourse on academic conference travel, which we would like to comment on.

While we argue in favor of less travel-intensive conference practices, we do not disregard arguments cautioning against change, nor do we call for all international exchange to be conducted virtually. Further, we acknowledge that changing conference travel practices might come with disadvantages. Nevertheless, we deem change necessary to secure the continued credibility and legitimacy of environmental psychology, and invite our community to think creatively about how disadvantages can be minimized or transformed into benefits.

MATERIALS AND METHODS

In February 2022, we distributed an online survey among ECRs in environmental psychology by using our professional networks (e.g., mailing lists, Twitter, Slack) and by directly contacting researchers in countries underrepresented in those networks. We aimed to gather quantitative data on how other ECRs in environmental psychology think about the future of conferences in environmental psychology. The survey included questions about participants' perceptions of current conference travel practices, their opinions regarding changing conference practices, and more specifically their views on virtual and hybrid conferences. Additionally, we used open-ended questions (**Supplementary Tables 1–9**) to elicit participants' suggestions and ideas for less travel-intensive conference practices.

We applied particular caution not to lead participants in their survey responses. Firstly, we started the survey with general questions on current conference travel practices and different conference formats, mentioning flying in particular only later in the survey. Secondly, we interspersed more morally loaded questions with more neutral questions on the use and liking of different conference formats.

We obtained responses from 117 ECRs[1] living in 32 countries. The majority of participants were Ph.D. students (54%) and worked on climate change-related topics as opposed to other topics in environmental psychology (81%). Overall, participants seemed to have some prior experience with conferences, having attended *Mdn* = 6.00 (range = 0–48) in-person conferences and *Mdn* = 3 (range = 0–15) virtual conferences throughout their academic career. In a typical year before the COVID-19 pandemic, 77% of participants flew to conferences once a year or less. For more demographic data see **Table 1**.

Data were analyzed in IBM SPSS Statistics (IBM Corp, 2020), RStudio (RStudio Team, 2015), QDA Miner (LaPan, 2013), and NVivo (Welsh, 2002). The full questionnaire as well as the anonymized dataset can be found on the Open Science Framework.[2] We present the results of the survey in the following Sections "Why International Conference Travel Practices need to Change" and "How International Conference Travel Practices Can be Changed," alongside our own arguments for less travel-intensive conference practices. We chose this structure to facilitate cross-comparison between our views and those held by other ECRs in environmental psychology. Unless otherwise indicated, all variables were measured on a scale from 1 (strongly disagree) to 7 (strongly agree).

TABLE 1 | Sample description.

	N	%	M, SD
Gender			
Female	67	57%	
Male	46	39%	
Non-binary	2	2%	
No answer	2	2%	
Position			
Postgraduate researchers not holding/doing a Ph.D.	12	10%	
Ph.D. students	63	54%	
Postdocs	23	20%	
Senior researchers/lecturers	7	6%	
Professors	12	10%	
Conference experience			
Never having attended an in-person conference	14	12%	
Never having attended a virtual conference	8	7%	
Age (23–50)			31.22, 5.06

WHY INTERNATIONAL CONFERENCE TRAVEL PRACTICES NEED TO CHANGE

We believe that current travel-intensive conference practices need to change because they pose a direct threat to the environment. Mainly due to attendee travel, in-person conferences are associated with large amounts of CO_2 emissions (van Ewijk and Hoekman, 2021). As technological advancements will likely not sufficiently reduce the aviation industry's emissions (Grewe et al., 2021), additional behavior change is required to meet global emission reduction targets.

The survey participants also believed that flying to conferences harms the environment ($M = 6.47$, $SD = 0.96$). On average, participants wanted conference travel practices in environmental psychology to change ($M = 5.62$, $SD = 1.45$), thought flying to conferences should be reduced ($M = 6.00$, $SD = 1.12$), and perceived the number of researchers who want to reduce emissions from conference travel to be growing ($M = 5.68$, $SD = 1.22$). In their responses to open-ended questions, participants also expressed the belief that it was important for travel norms in our community to change.

More indirectly, travel-intensive conference practices also pose a risk to our scientific discipline. If we as environmental psychology researchers do not reduce our air travel, it may

[1]We define ECRs as postgraduate researchers, and researchers currently doing their Ph.D. or within 7 years of having completed it, in line with the definition applied by the European Research Council (ERC, 2022).

[2]https://osf.io/86eay

negatively affect our credibility when communicating the need for behavior change to the public (Le Quéré et al., 2015; Attari et al., 2016). Inconsistencies between our call for change and our behavior may be actively instrumentalized to promote discourses of climate delay (Lamb et al., 2020), and even those with no interest in delaying climate action may doubt that climate change requires urgent action if experts on this topic behave unsustainably. Importantly, criticism of sustainability researchers' behavior is often presented in bad faith. Thus, aiming to satisfy all demands for ethical purity is futile (Goodwin, 2020). Nevertheless, we think that the environmental psychology community should act as role models by systematically addressing the largest sources of emissions in their professional carbon footprints.

In line with these arguments, participants on average somewhat agreed that flying to conferences harms our credibility ($M = 5.12$, $SD = 1.71$) and somewhat disagreed that such behavior was in line with being a role model for the public ($M = 2.69$, $SD = 1.65$; reverse-coded) or with leading by example for other scientific disciplines ($M = 2.85$, $SD = 1.71$, reverse-coded). They considered protecting the environment ($M = 6.60$, $SD = 1.09$) and the credibility of researchers in our field ($M = 5.25$, $SD = 1.77$) compelling reasons to reduce flying to conferences, on a scale from 1 (a very bad reason) to 7 (a very good reason). Being a role model for the public ($M = 5.74$, $SD = 1.59$) and leading by example for other scientific fields ($M = 5.72$, $SD = 1.51$; measured on the same scale) were also considered important.

Additionally, we experience tension between our closely held sustainability values and the behavior required by conference travel norms. This causes cognitive dissonance and thus discomfort (Festinger, 1957). Like us, many ECRs in environmental psychology are strongly motivated in their work by their wish to help avert a climate crisis. On average, the survey participants indicated that mitigating climate change ($M = 6.65$, $SD = 0.63$) as well as having low carbon footprints in their professional ($M = 6.11$, $SD = 0.91$) and private lives ($M = 6.27$, $SD = 0.91$) is important to them. When we asked participants why they became researchers or why they chose to work on environmental psychology topics in particular, "wanting to change the world for the better," and not least "mitigating climate change" were among the most frequently stated motivations (**Supplementary Tables 1, 2**). Significantly, participants also believed that it was important to advance their careers ($M = 6.03$, $SD = 1.09$). Thus, ECRs in environmental psychology may find themselves in a situation of conflicting priorities.

Concerns about the negative consequences of travel-intensive conference practices were also reflected in ECRs' emotions and norms. Participants thought their colleagues should not fly to conferences ($M = 5.00$, $SD = 1.55$), but did not perceive a similar expectation toward themselves from their colleagues ($M = 3.89$, $SD = 1.55$). On a scale of 1 (never), 2 (rarely), 3 (sometimes), 4 (often), and 5 (every time), they reported often feeling bad about their conference air travel emissions ($M = 3.92$, $SD = 1.11$), and sometimes worrying about being criticized for it ($M = 2.81$, $SD = 1.33$) although they had rarely been criticized yet ($M = 2.20$, $SD = 1.30$). They did not experience any do-gooder derogation (see Minson and Monin, 2012), reporting that they rarely got criticized for not flying to conferences ($M = 1.87$, $SD = 1.31$) and also rarely worried about it ($M = 2.02$, $SD = 1.14$).

We think that travel-intensive conference practices are in tension with the very values and moral aspirations underlying our research, at least for those working on climate change topics. Resolving such tensions as far as possible would make it easier for researchers strongly rooted in these moral concerns to work in academia. It may even retain some researchers who might otherwise leave academia for less travel-intensive careers. Although only 5% of the participants knew of someone who had left academia because they could not or did not want to keep up with travel requirements, 13% had themselves considered leaving academia for this reason.

Equally as important as the threat to the environment, current conference travel practices are associated with considerable inequities reflected in as well as perpetuated by inequalities of access to conferences. Academic air travel is strongly predicted by one's geographic location and family commitments (Whitmarsh et al., 2020). Those facing visa issues or lacking funding for (long-distance) travel are systematically disadvantaged by in-person conferences (McInroy, 2018). Caretaking responsibilities and physical or mental disabilities or illnesses similarly inhibit travel (Bradley et al., 2020; Henderson, 2021). More recently, travel regulations put in place due to the COVID-19 pandemic (e.g., tests and vaccinations as entry requirements) may place additional travel burdens on some (Matthies et al., 2021).

Participants also believed that flying to conferences reinforces existing inequalities ($M = 5.81$, $SD = 1.30$). Although on average participants said they could participate in their field's conference travel practices without major difficulties ($M = 4.60$, $SD = 1.82$), a substantial minority of 29% indicated they could not; especially researchers who indicated they were from the Global South ($M = 2.82$, $SD = 2.32$, $n = 11$[3]) or facing visa challenges ($M = 2.85$, $SD = 1.91$, $n = 13$). In contrast, participants who did not identify as members of any disadvantaged group (including all of the groups in **Figures 1**, **2** and any other group they wished to name) were able to participate easily ($M = 5.80$, $SD = 1.01$, $n = 17$).

HOW INTERNATIONAL CONFERENCE TRAVEL PRACTICES CAN BE CHANGED

To us, the question is not whether conference travel practices should change, but how we should change them. Our discourse needs to shift toward best practices and creative visions of what successful, less travel-intensive conferences could look like. We do not postulate that change must happen in a specific way. Rather, we believe it will require the ingenuity of our whole community to find ways to move forward. Nevertheless, we wish to provide a few examples of less travel-intensive conference practices.

[3]This includes $n = 1$ person living in the United States and $n = 1$ living in Australia, which self-reported to be part of the Global South, although neither country is part of the Global South according to common definitions (UNDP, 2004).

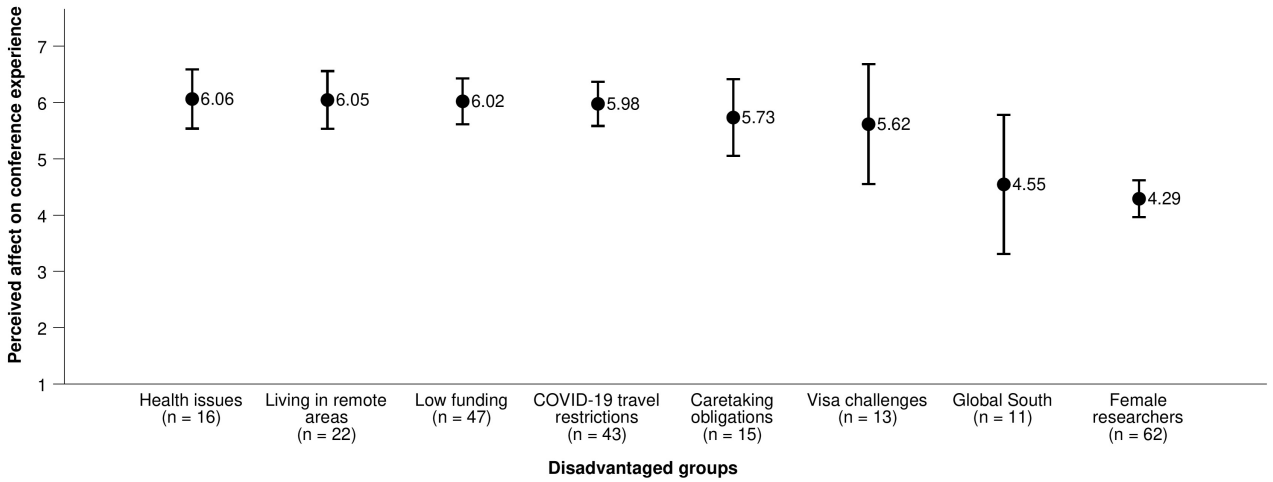

FIGURE 1 | How a virtual conference format would affect the conference experience of participants' groups. Variables were measured on a scale from 1 (it would make their experience much worse) and 7 (it would make their experience much better). Error bars represent 95% confidence intervals.

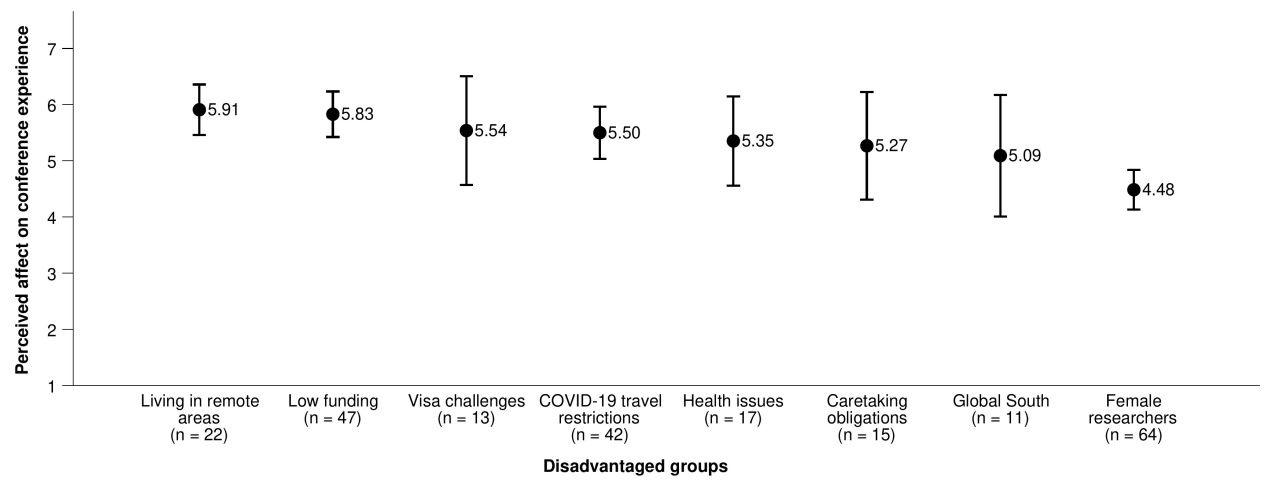

FIGURE 2 | How a hybrid conference format would affect the conference experience of participants' groups. Variables were measured on a scale from 1 (it would make their experience much worse) and 7 (it would make their experience much better). Error bars represent 95% confidence intervals.

The most common alternatives to in-person conferences are virtual or hybrid conferences. While interactions take place entirely online at virtual conferences, hybrid conferences allow for both in-person and virtual participation. Hybrid conferences may be held in one central location and also allow for virtual participation, or attendees may meet in local hubs on different continents or countries and connect virtually across them (Kuper, 2019). Virtual conferences can reduce conference emissions by up to 94%, hybrid conferences by 60–70% (Tao et al., 2021). Additionally, there are other measures to minimize travel emissions from conferences (see Kreil, 2020). Train travel may be promoted by providing booking support for train trips and financial compensation (Hartmann et al., 2019). Annual international conferences could be changed to a biennial cycle or alternate between a virtual and in-person format. Conferences could be held at locations that minimize travel emissions across all attendees (Klöwer et al., 2020). Alternatives suggested by participants included: regional conferences, choosing local conference hubs that are virtually connected, incentivizing and promoting train travel, and ensuring sustainable food and accommodation (see **Supplementary Table 3**).

An important question is whether virtual/hybrid conferences can deliver the same benefits as in-person conferences. Answering this question is crucial because participants expressed a belief that conference travel is beneficial for their career, both in the quantitative data ($M = 5.71$, $SD = 1.34$) and in their responses to open-ended questions. Participants also expected their conference experience[4] to become somewhat worse upon switching to virtual conference formats [$M = 3.51$, $SD = 1.59$;

[4]Conference experience was defined as both ease of access to and quality and usefulness of the conference.

scale from 1 (It would make my experience much worse) to 7 (It would make my experience much better)], although they were optimistic that virtual conferences would improve within the next 5 years [$M = 5.36$, $SD = 1.48$; on a scale from 1 (not at all optimistic) to 7 (very optimistic)]. They expected a somewhat better conference experience when switching to hybrid formats ($M = 4.53$, $SD = 1.63$). When they rated the usefulness (on a scale from 1 to 10) of the best, worst, and average in-person and virtual conferences they had attended, virtual conferences were consistently rated lower than in-person ones (**Table 2**). However, the best virtual conferences ($M = 6.46$, $SD = 2.15$) received similar ratings as the average in-person conferences participants had attended ($M = 6.88$, $SD = 1.39$).

Commonly discussed disadvantages of virtual and hybrid conferences include time-zone differences, screen fatigue, or technical issues (e.g., Foramitti et al., 2021). However, the biggest disadvantage of virtual conferences is perceived to be the lack of informal and social exchange and chances to network (Foramitti et al., 2021; Matthies et al., 2021; Wenger, 2021). This was confirmed by our qualitative data, as formal sessions were considered easy to conduct virtually, whereas informal chats and spontaneous exchanges, socializing (e.g., during coffee or lunch breaks), networking with new people, and forming relationships were considered difficult to realize virtually (**Supplementary Table 4**).

However, some participants thought that informal and social interactions could indeed be facilitated virtually (**Supplementary Table 5**). Some said it was easy to conduct planned informal chats and small group discussions, that online tools and platforms could be used for virtual social activities such as team games, and that chat forums and other interactive platforms could help to network and foster information exchange (**Supplementary Tables 5, 6**). Several participants shared our opinion that difficulties around informal interaction must be carefully considered in the planning of virtual/hybrid conference formats (e.g., planned sessions for networking and informal exchange; **Supplementary Table 6**).

Similarly, quantitative data suggested that participants were of mixed opinions regarding their ability to build and maintain professional relationships through virtual communication, reflected in a clearly bimodal distribution of responses. On a scale from 1 (very unlikely) to 7 (very likely), 39% said it was (very or somewhat) unlikely that they could build new professional relationships virtually, while 55% said it was (very or somewhat) likely ($M = 4.28$, $SD = 1.62$). Maintaining already established professional relationships through virtual communication was considered more achievable ($M = 5.25$, $SD = 1.39$).

Prioritizing informal exchanges in virtual conference planning could help to build and maintain strong bonds with each other. Our community already has great structures and networks in place, which have been built over the past years and from which ECRs can now benefit (e.g., there are many local networks, events, and conferences, albeit with large geographical inequalities). Thanks to recent technological developments as well as conference organizers' creativity, several formats have emerged that address perceived shortcomings of current virtual conferences (Song et al., 2021; see https://thefutureofmeetings.wordpress.com/tools/ for a list of tools for virtual communication). One particularly noteworthy recent example of such formats is a mentoring program that paired junior researchers with senior researchers based on their interests, aiming to have informal virtual chats throughout the conference to network (Sips Society for the Improvement of Psychological Science [SIPS], 2021).

TABLE 2 | Usefulness of the best, worst, and average in-person and virtual conferences participants had attended.

	In-person conferences		Virtual conferences	
	M	SD	M	SD
Best attended conferences	8.13	1.71	6.46	2.15
Average attended conferences	6.88	1.39	5.42	1.85
Worst attended conferences	4.35	2.02	3.10	1.94

Variables were measured on a scale from 1 (extremely useless) to 10 (extremely useful).

New Formats Provide an Opportunity to Reduce Existing Inequalities and Promote Equity

Switching to alternative conference formats could at least partially alleviate travel burdens experienced disproportionally by the disadvantages mentioned in the Section "Why International Conference Travel Practices Need to Change." Virtual conferences increase attendance and diversity, especially with respect to gender, geographic location, and career stage (Sarabipour, 2020; Skiles et al., 2021). For virtual and hybrid conferences, most attendees benefit from savings in time and money (Sarabipour, 2020; Foramitti et al., 2021). Researchers with disabilities (e.g., deaf and hard of hearing), an often-overlooked disadvantaged group, can benefit from unique features of virtual conferences such as the addition of subtitles to recorded talks (Huyck et al., 2021). Virtual conferences may also increase ECRs' active participation through reducing social anxieties (Estien et al., 2021). In line with this, participants considered reducing inequalities a compelling reason to change current conference travel practices [$M = 5.89$, $SD = 1.44$, on a scale from 1 (a very bad reason) to 7 (a very good reason)].

Nevertheless, new conference formats may also introduce or exacerbate inequalities. For example, the funding available to a researcher might dictate whether they attend a given hybrid conference virtually or in person. For some, virtual participation may be the only possibility to participate at all. Vice versa, the mere option of inexpensive virtual participation might keep institutions from funding costlier in-person participation, thus also preventing some from attending in person. This might introduce systematic differences in the quality of the conference experience for different groups of researchers. Similarly, a conference location that minimizes the total travel emissions across all attendees would systematically disadvantage those living in more remote locations. We do not condone such effects,

and urge the community to focus on developing alternatives which improve, rather than impair, equality of access.

In practice, the positive and negative impacts of changing conference travel practices for specific groups in specific circumstances must be carefully evaluated and weighed. Our survey data supports this view. Participants with health issues, visa challenges, caretaking obligations, COVID-19 travel restrictions, low funding, or living in areas remote from centers of academic activity thought that the conference experience of researchers in their own disadvantaged group would improve through switching to virtual or hybrid conferences (**Figures 1**, **2**). However, it is noteworthy that the same participants did not necessarily expect positive impacts for themselves to the same extent (**Supplementary Figures 1, 2**).

Collective Solutions Can Change the Rules of the Game and Create Equal Conditions for All

We believe that many actors in academia have a role to play in this transformation toward less travel-intensive conference practices, and that the responsibility can neither be put solely on individuals nor solely on collective entities. In accordance with this view, participants considered changing conference travel practices a shared responsibility, with themselves ($M = 5.71$, $SD = 1.18$), the research community ($M = 5.93$, $SD = 1.07$), conference organizers ($M = 6.03$, $SD = 1.02$), and employing institutions ($M = 5.48$, $SD = 1.47$) responsible for making changes. In the open-ended "Other" category, participants indicated that they also considered governments and states ($n = 8$), policymakers ($n = 7$), and funding agencies ($n = 5$) responsible (**Supplementary Table 7**).

Here, it is crucial to emphasize the particular importance of collective and institutional changes. Both are needed to support individual behavior change by mitigating negative consequences of individual behavior change. For example, in discussions of academic air travel, many researchers express concern for the career opportunities of ECRs who choose not to fly, or would not be able to, if we collectively, as a discipline, decided not to fly.

Indeed, participants expected to be put at a slight disadvantage compared to researchers at their own career stage ($M = 4.87$, $SD = 1.59$) and further along the career path ($M = 4.96$, $SD = 1.59$) if only they themselves chose to fly less to conferences. However, in line with our argument above, participants did not think that they would be put at a disadvantage if everyone in the field flew less, both compared to those at their own career stage ($M = 2.76$, $SD = 1.49$) and those at higher career stages ($M = 3.19$, $SD = 1.70$). This underlines the importance of seeking collective solutions. We recognize the unique role of conference organizers as a relevant stakeholder group to initiate collective change in conference travel practices. However, the burden of change should not be placed exclusively on conference organizers. They should be supported in change by other relevant stakeholders like universities, professional associations of psychologists, and external stakeholders (e.g., sponsors, or municipalities where conferences are held).

DISCUSSION

We have presented arguments in favor of switching to less travel-intensive and thus more sustainable and equitable conference practices in environmental psychology. Additionally, we present empirical insight into what the international community of ECRs in environmental psychology thinks on this topic.

Participants believe that conference travel practices should change, and that flying to conferences should be reduced in particular. This belief may stem from their sustainability values, which motivated many to work on environmental psychology, or from their difficulties in complying with current travel norms. Participants consider reducing flying necessary to protect the environment and promote equity by reducing inequalities in academia, but also to preserve our community's credibility and ability to lead by example. A minority of the participants has even considered leaving academia because they could not or did not want to comply with travel practices. This, and the fact that the participants perceive the number of researchers wanting to reduce their travel emissions to be growing, should give us pause for thought.

The ECRs we surveyed consider conferences beneficial for their careers. Thus, we want to emphasize that abolishing conferences or conference travel is not our intention. Instead, we advocate for less travel-intensive conference practices that can deliver similar benefits. Participants rated the best virtual conferences they had attended to be similarly useful as the average in-person conference, despite the relatively few experiences participants reported, and the relatively recent rise of widespread virtual conferencing. This indicates a great future potential of virtual conferences and underlines the importance of developing and sharing best practices. Participants share our optimism about the future development of virtual communication.

Overall, participants expect their conference experience to worsen somewhat with a switch to virtual (but not hybrid) conferences. However, ECRs belonging to disadvantaged groups expect a switch toward virtual or hybrid conferences to positively affect their groups. Interpretation is complicated by the fact that the same participants did not necessarily expect positive effects for themselves, but it is notable that expectations may differ by group. Future debates on conference formats should explicitly include diverse perspectives, and future research should investigate the differential impacts of different conference formats on specific groups.

While the participants think professional relationships can be maintained virtually, they are divided on whether relationships can be built that way. This finding is in line with the literature (Foramitti et al., 2021; Wenger, 2021), and suggests that preserving the value of conferences in a virtual/hybrid setting depends on careful organization with a focus on facilitating informal interaction and relationship building.

Participants expect to be put at a career disadvantage relative to their peers and seniors only if they alone decide to fly less to conferences, but not if everyone does. This exemplifies the social dilemma nature of climate change and pro-environmental behavior (Milinski et al., 2008). Specifically, it underlines the necessity to make changes collectively in order

to change the rules of career success in our community. It also resonates with literature indicating that even highly motivated individuals do not always translate their environmental attitude into pro-environmental behavior due to external constraints (Kollmuss and Agyeman, 2002; Gifford, 2011). Expected career disadvantages may be one such constraint playing an important role.

The survey results indicate that ECRs in environmental psychology view the responsibility for change as a shared responsibility between many different actors. We agree, but wish to emphasize the strategic position of conference organizers as a promising locus of intervention. Conference organizers are situated at the crossroads of relations between stakeholders of the community. They connect internal and external stakeholders, universities, and local agents (e.g., the municipality where the conference is held) and have to harmonize demands coming from all of them. We are aware that organizers operate under constraints, and that organizing conferences comes with a risk, which is exacerbated if a new conference format is implemented without knowing how many community members endorse that format. However, we hope that the data provided here—including qualitative data on participants' visions for high-quality virtual/hybrid conferences—can offer some orientation and encouragement.

LIMITATIONS

By recruiting participants for our survey through our professional networks, we introduced a sample bias toward participants similar to ourselves. To make our sample more diverse, we directly contacted researchers from regions underrepresented in our networks, but certain countries are still overrepresented. The sample also does not include those who have already left research. Despite our efforts to avoid leading participants' responses, some social desirability bias may have influenced the data. Also, ECRs may have been more likely to participate if they had strong feelings about conference travel, although we intentionally kept the survey invitation vague. Finally, our sample is too small to draw broader conclusions for ECRs in general, but may permit some generalization for environmental psychology, given the relatively small size of our community.

CONCLUSION

Our community case study shows that ECRs in environmental psychology recognize the value of conferences, but have concerns about the impact of current conference travel practices on researchers' credibility, equity in academia, and the environment. They largely support a shift toward less travel-intensive conference practices including flying less. At the same time, they experience current virtual conferences as less useful than in-person ones, expect a somewhat worse conference experience in the case of a switch toward virtual conferences, and many do not believe they can build professional relationships virtually.

These concerns about both current and alternative conference travel practices must be taken seriously. We call on our community to try hard to face this challenge with optimism. We wish for the community to apply the same creativity we have cultivated in developing psychological behavior change interventions to working to overcome shortcomings of less travel-intensive conference practices.

In particular, this requires a focus on conference travel practices that decrease, not increase, inequalities, and that facilitate informal interaction and networking. To achieve this, we should look to best practices in the wider scientific community (Achakulvisut et al., 2020; Richter et al., 2021; Eidgenössische Technische Hochschule Zürich [ETH], 2022). We further need to build and strengthen the skills needed for virtual community building. Workshops where diverse groups of environmental psychologists and other stakeholders co-develop solutions can ensure that the needs of all stakeholders are considered.

Although devising and implementing less travel-intensive conference practices is a shared responsibility of collective entities and individuals in our field, conference organizers may be particularly well-placed to lead this transformation. We hope this manuscript shows organizers that efforts to reduce conference travel emissions will be welcomed by many ECRs in our field.

DATA AVAILABILITY STATEMENT

The full survey and dataset presented in this study can be found in an online repository under the following link: https://osf.io/86eay/.

ETHICS STATEMENT

This study involving human participants was reviewed and approved by the ETH Zurich Ethics Commission (EK 2021-N-233). The participants provided informed consent to participate in the study.

AUTHOR CONTRIBUTIONS

JK and ASK: conceptualization, methodology, investigation, formal analysis, data interpretation, writing—original draft, writing—review and editing, and visualization. AW: conceptualization, methodology, investigation, formal analysis, data interpretation, writing—review and editing, visualization, and ethics proposal. EK: methodology, investigation, formal analysis, data interpretation, and writing—review and editing. VH, VM, AD, and SL: methodology, investigation, data interpretation, and writing—review and editing. CG, CH, MM, and CR: methodology, investigation, and writing—review and editing. All authors read and approved the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.906108/full#supplementary-material

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Predicting Pro-environmental Intention and Behavior Based on Justice Sensitivity, Moral Disengagement, and Moral Emotions – Results of Two Quota-Sampling Surveys

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The effects of climate change lead to increasing social injustice and hence justice is intrinsically linked to a socio-ecological transformation. In this study, we investigate whether justice sensitivity motivates pro-environmental intention (PEI) and behavior (PEB) and, if so, to what extent emotions and moral disengagement determine this process. For this purpose, we conducted two quota-sampling surveys (Study 1: N = 174, Study 2: N = 880). Multiple regression analyses in both studies suggest that a higher perception of injustice from a perpetrator's, beneficiary's, and observer's perspective is associated with an increased PEI. However, moral disengagement best predicted PEB and PEI. Guilt and authentic pride were found to be emotional predictors of PEI. Additionally, mediation analyses demonstrated that guilt mediates the connection between both perpetrator and beneficiary sensitivity and PEI. These results suggest that when the predominant originators of climate change (i.e., individuals from industrialized countries) perceive global climate injustice from the perspective of a beneficiary or a perpetrator, they experience guilt and have a higher PEI. Based on this mechanism, it seems promising to render global injustice more salient to those responsible for activities that lead to climate change to motivate them to adapt their behavior. The role of moral disengagement and victim sensitivity as barriers to pro-environmental behavior is discussed in this context.

Keywords: justice sensitivity, climate justice, moral disengagement, moral emotions, pro-environmental behavior, pro-environmental intention, behavior change

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INTRODUCTION

The latest report by the Intergovernmental Panel on Climate Change [IPCC] (2022) suggests that it is not only natural conditions that determine who is most affected by the climate crisis, but rather the living conditions of the individuals. Limited economic resources, suffering from inequality, enduring political instabilities and wars, or limited access to basic resources such as clean water

are only a few examples of disadvantages faced by individuals due to climate change. Ultimately, human rights, such as the right to life, health, and subsistence are endangered by the consequences of climate-damaging behavior, i.e., behavior that emits a lot of greenhouse gases and, therefore, forces climate change. Due to unequally distributed resources (e.g., money, political power), climate change disproportionally affects the Global South, younger generations, women, and people with low income more intensely than the Global North, older generations, men, and people with high income (Intergovernmental Panel on Climate Change [IPCC], 2022). In all of these cases, the same disproportion can be found, namely that the individuals who are least responsible for climate change are more affected by its consequences than those most responsible for it. For example, from 1990 to 2015, the global wealthiest 10% were responsible for 46% of emission growth whereas the global poorest 50% were responsible for only 6% of the total emission growth (Kartha et al., 2020). As a consequence, discussions concerning climate change comprise ethical and moral issues regarding justice (Caney, 2010; Boom et al., 2016; De Smet et al., 2016; Alves and Mariano, 2018). Therefore, the term *climate justice* incorporates various justice principles in the domain of climate change. These include *distributive justice*, which considers the allocation of costs and benefits among people, *procedural justice*, which points out who can participate in decision-making processes, and *recognition*, which involves respectful and appropriate "consideration of diverse cultures and perspectives" (Intergovernmental Panel on Climate Change [IPCC], 2022, p. 9).

Justice was found to be a fundamental human motive (Montada, 2007; Baumert et al., 2013a). Therefore, we hypothesized that justice is not only the target but also a cause of pro-environmental intention, and, in turn, a motivator of pro-environmental behavior. Hence, we investigated whether justice sensitivity motivates individuals to behave (more) pro-environmentally. In this article, we apply findings from justice sensitivity research to the context of the current climate crisis and investigate the predictive power of justice sensitivity toward the intention of a pro-environmental behavioral change. Moreover, we investigate the associations of pro-environmental behavior change with moral emotions and moral disengagement.

In the context of climate justice, people in industrialized countries can be regarded as the beneficiaries of the detrimental living conditions of people from less developed countries, since the standard of living in industrialized countries is directly connected to the exploitation of natural and human resources in less developed countries (Dorninger et al., 2021; Hickel et al., 2022). However, many people may not be completely aware of this fact as the actions that result in driving climate change are probably perceived as an "unintentional, if unfortunate, side effect" of goal-directed behavior (Markowitz and Shariff, 2012). Markowitz and Shariff (2012) call this phenomenon the *blamelessness of unintentional action*. Unintentionally caused consequences are judged less harshly than equally severe but intentionally caused consequences (Guglielmo et al., 2009). However, the existence or lack of an intention does not change the consequences of an action. Therefore, we hypothesize that people need to identify themselves as responsible to renounce their privileges and act in solidarity with the disadvantaged. Moreover, we assume that this perception is a motivator for pro-environmental behavior change and, therefore, is pivotal to achieving climate justice. Consequently, we focus on justice sensitivity in this article. In the following, we contextualize the role of justice sensitivity on pro-environmental behavior and intention by investigating the joint prediction of pro-environmental behavior and intention with justice sensitivity, emotions, and moral disengagement.

Justice was found to be a fundamental human motive (Montada, 2007; Baumert et al., 2013a). That is, individuals generally seek to establish justice while avoiding injustice (Lerner, 1977), and hence individuals want themselves and others to be treated fairly and are willing to behave according to justice principles (Baumert et al., 2013b). To establish justice, individuals are willing to give up their own advantages (Engel, 2011), act sustainably (Kals and Becker, 2006), or reject a beneficial but unfair deal (Sutter et al., 2020). A meta-analysis based on 182 studies on collective behavior confirmed that the more strongly individuals perceive a situation to be unjust, the more likely they are to participate in collective action (such as protest behavior) to improve the situation (van Zomeren et al., 2008). Baumert et al. (2013b) summarize:

> Assuming that justice is a fundamental motive for individuals means that the perception of a potential injustice triggers emotional reactions (e.g., anger, moral outrage, compassion, guilt) and urges the individual to act in order to restore justice or to avoid the injustice. Hence, the concept of a human justice motive implies the assumption of a psychological link between the perception of (potential) injustice and affective and behavioral reactions (p. 161).

Although justice is a fundamental motive, individuals differ in their judgments concerning whether a situation (e.g., the climate crisis) is just or unjust. These differing assessments were found to be due to different principles of justice that vary across different individuals, contexts, situations, and relationships (Deutsch, 1985; Jasso et al., 2016; Sabbagh and Schmitt, 2016; Skitka et al., 2016). In this article, we focus on the first aspect, namely individuals. Dispositional interindividual differences were found to influence the perception of justice, i.e., differences in *justice sensitivity* (Lerner, 1977; Münscher, 2017; Preiser and Beierlein, 2017). Justice sensitivity is regarded as a personality trait (Schmitt et al., 1995), as it was found to be consistent across situations and contexts (Schmitt et al., 2009). Justice sensitivity is defined as the tendency to perceive injustice that results in negative emotional responses. Together, the perception of injustice and its negative evaluation form action tendencies to mitigate the injustice (Baumert and Schmitt, 2016). This process is in line with the appraisal theory developed by Arnold (1960), which states that emotions, i.e., action tendencies, are the result of two cognitive processes: the factual cognition (here: Is the situation just or not?) and the evaluative cognition (here: evaluating injustice as negative – or positive).

Individuals react with different intensity to injustices they have suffered themselves (as victims), to injustices they perceive in everyday situations (as observers), to injustices from which

they passively benefit (as beneficiaries), and to injustices they have committed themselves (as perpetrators; Montada and Maes, 2016). Although justice sensitivity is inherent to all four perspectives, they differ in several ways. On the one hand, a high justice sensitivity as an observer, beneficiary, or perpetrator reflects the desire for justice for others and a feeling of social responsibility. On the other hand, a high score in justice sensitivity as a victim reflects a desire for justice for oneself (Preiser and Beierlein, 2017). More precisely, individuals who score highly in perpetrator or beneficiary sensitivity rather experience prosocial concerns (e.g., existential guilt, social responsibility, or solidarity with the disadvantaged; Gollwitzer et al., 2005). Observer sensitives were found to feel empathy and, as a result, take responsibility (Schmitt et al., 2005). Those who perceive injustice from the perspective of the beneficiary, observer, or perpetrator are more likely to feel responsible (Ehrhardt-Madapathi et al., 2018). A greater sense of responsibility, in turn, is a promising predictor to engage in pro-environmental behavior (Kollmuss and Agyeman, 2002). As already indicated, victim sensitivity relates differently and in part contrarily to the other three perspectives. In terms of behavioral outcomes, victim sensitivity was positively related to delinquent behavior (e.g., fare or tax evasion; Preiser and Beierlein, 2017). Victim sensitives are afraid of being disadvantaged and behave in anticipation of such an injustice. Therefore, they easily abandon their moral standards (Gollwitzer et al., 2009; Schmitt et al., 2009; Münscher, 2017; Preiser and Beierlein, 2017), are rather jealous, neurotic, socially mistrusting, and paranoid (Schmitt et al., 2005) and fear the exploitation of their investments (Rothmund et al., 2014). To summarize, we can distinguish three pro-social sensitivities (perpetrator, beneficiary, and observer) from one pro-self sensitivity (victim). We assume that the three pro-social sensitivities are positively associated whereas the pro-self sensitivity is negatively associated with pro-environmental intention and behavior.

These associations are mirrored in emotional dispositions as individuals with a higher score in beneficiary or perpetrator sensitivity are more prone to experience guilt than those with a lower score. In contrast, individuals with a higher score in observer sensitivity tend to more easily be outraged than those with a lower score. Finally, individuals with a higher score in the area of victim sensitivity are inclined to feel more anger than those with a lower score (Preiser and Beierlein, 2017).

Emotions – especially, moral emotions – affect environmentally relevant behavior (Kals and Maes, 2002; Hahnel and Brosch, 2018; Harré, 2018; Landmann, 2020), and, therefore, are of particular interest in the area of climate injustice. We refer to *moral emotions*, as they "inhibit socially undesirable behavior and foster moral conduct" (Tangney, 1995). For example, in a study by Roeser (2012), in climate change communication, emotions promoted a better understanding of the moral meaning of climate change in comparison to neutral communication. As a consequence, emotions are a reliable motivator for pro-environmental behavior (Roeser, 2012). Corral-Verdugo (2013) even found that emotions have a higher impact on pro-environmental behavior than intentions. More precisely, emotions and intentions together explained more than half of the variance in pro-environmental behavior. In addition, emotions play a vital role in initiating behavioral *change* (Stoll-Kleemann et al., 2022a). Kollmuss and Agyeman (2002) state in their behavior change model that "the stronger a person's emotional reaction, the more likely that person will engage in a new behavior."

When speaking about the influence of emotions on pro-environmental behavior, we can distinguish between (1) emotions that are currently experienced, (2) emotions that people believe their actions will elicit (anticipated emotions), and (3) emotions that are generalized due to multiple repetitions. Venhoeven et al. (2013) also address the emotions that pro-environmental behavior elicits, although their findings are not relevant to this study. The three aforementioned emotion groups cause different effects. First, experimentally induced current emotions, e.g., by confronting participants with environmental damages to elicit guilt (Reese and Jacob, 2015), affected the pro-environmental intention or behavior of these individuals. However, these effects were found to be rather small, vary individually, and not remain stable over a period of time (Landmann, 2020, p. 10). Second, anticipated emotions can motivate people to engage in pro-environmental behavior as they either believe it will make them experience pleasure (Rezvani et al., 2017) or prevent them from experiencing displeasure (Onwezen et al., 2013). Third, according to the model of affect generalization (Paolini et al., 2016), emotional episodes can generalize when experienced sufficiently often or with high intensity. In the context of pro-environmental behavior, Landmann (2020) states that emotions only affect behavioral intentions if they are generalized. In line with the model of affect generalization, the emotions used in this work are not used as an emotional episode (currently experienced or anticipated), but rather as an affective attitude, that is, the proneness to feel these emotions.

In this study, we investigate the role of the moral emotions (1) pride, (2) gratitude, (3) guilt, and (4) shame. Considering the seven categories of environmentally relevant emotions by Landmann (2020), pride is one of the *self-praising emotions* which occur as a result of positive norm deviations. Gratitude belongs to *other-praising emotions* which are triggered by observing positive norm deviations in others. Guilt and shame cover *self-condemning emotions* that arise due to individual violations of personal norms. These different emotion types lead to different action tendencies. Whereas self-praising emotions reinforce one's own positive behavior, e.g., through in-group favoring pro-environmental intentions, other-praising emotions lead to support for the source of these emotions, e.g., protecting nature. Self-condemning emotions motivate people to correct their behavior, e.g., by repairing environmental damage (Landmann, 2020).

Rezvani et al. (2017) found that when people anticipated feeling *pride* due to their pro-environmental behavior, they had a higher pro-environmental intention than individuals without this anticipation. Additional to this direct effect, anticipated pride also mediated the effect of personal moral norms on pro-environmental intentions. Experienced pride in environmental behavior increased an individual's engagement in pro-environmental behavior (Bissing-Olson et al., 2016).

However, two types of pride can and should be distinguished: *authentic* and *hubristic pride*. Authentic pride, on the one hand, focuses on the "self-in-action," e.g., pro-environmental behavior, and is therefore tied to specific situations. Hubristic pride, on the other hand, focuses on the "self-as-actor" and generalizes across situations. This difference impacts behavior: whereas authentic pride positively predicted moral behavior, hubristic pride was negatively related to it (Krettenauer and Casey, 2015).

Gratitude is benefit-triggered and can be considered a trait and therefore may serve as a second positive emotion. Tam (2022) found that gratitude correlated with pro-environmental intention and behavior. However, manipulations of gratitude toward nature did not have robust effects on pro-environmental behavior change.

Guilt and *shame* due to environmental damage were consistently found to influence pro-environmental intention and behavior (Carrus et al., 2008; Ferguson and Branscombe, 2010; Gausel and Brown, 2012; Harth et al., 2013; Rees et al., 2014). When individuals are highly perpetrator- or beneficiary sensitive, they are also prone to feel guilty (Montada et al., 1986). Guilt results from regretting a specific behavior afterward but does not affect one's self-identity. Shame, however, affects one's self-identity as it goes along with a feeling of worthlessness and powerlessness (Tangney, 1995). Therefore, guilt tends to be tied to a specific behavior (similar to authentic pride), whereas shame is linked to self-identity (similar to hubristic pride). Rees et al. (2014) found that both emotions predicted positive behavioral intentions, but it was shame and not guilt that transformed the intention into actual behavior. However, Carrus et al. (2008) showed that anticipated guilt strongly affected an individual's desire to use public transportation and engage in household recycling. The relationship between negative anticipated emotions and the pro-environmental intention was even stronger than that between attitudes and pro-environmental intention. Most research on emotions in pro-environmental behavior focused on guilt and pride. In direct comparison, pride and guilt were both significantly related to pro-environmental behavior and intention to engage in pro-environmental behavior. Shipley and van Riper (2022) found that anticipated pride and guilt had equal effects on pro-environmental behavior, but that experienced guilt had stronger effects on pro-environmental behavior than experienced pride. However, negative emotions must be dealt with consciously, as they result in aversive action tendencies. This is evident in the case of cognitive dissonance (Festinger, 1957). According to the theory of cognitive dissonance, emotional stress occurs when actions and beliefs are inconsistent. This emotional stress is highly uncomfortable and needs to be resolved. Based on Festinger's theory, Bandura (2007, 2016) developed the concept of *moral disengagement*. Moral disengagement can be seen as a cognitive restructuring of a situation to justify inaction or subjectively wrong action (Bandura et al., 1996; Bandura, 2007, 2016) and does not only occur in individuals, but also in groups of individuals when harmful behavior is collectively morally justified (Bandura, 2002). These justification mechanisms include denial and diffusion of responsibility. Euphemistic labeling, advantageous comparison, in addition to minimizing, ignoring, or misconstruing the consequences are also forms of moral disengagement. Engaging in these strategies can be prevented by a high degree of moral self-regulation, that allows individuals to remain consistent with their standards of justice. Such a higher moral self-regulation and, hence, less moral disengagement, was found in perpetrator and beneficiary sensitive individuals in a longitudinal study by Maltese and Baumert (2016). Bandura (2007) already theorized how moral disengagement selectively contributes to increasing environmental damage. These mechanisms prevent individuals from engaging in pro-environmental behavior, even if they have already recognized the injustice of their behavior. Some of the mechanisms were investigated in a qualitative study (Stoll-Kleemann and O'Riordan, 2020) while the association of moral disengagement with high carbon behavior was found in a quantitative study (Stoll-Kleemann et al., 2022b). It is assumed that moral disengagement in high carbon behavior correlates positively with victim sensitivity, as both tendencies are self-serving and prevent an individual from taking responsibility for the environment. Therefore, moral disengagement is also assumed to correlate negatively with pro-environmental intention and behavior.

As argued above, pro-environmental behavior change is necessary to achieve climate justice. We hypothesize that climate justice is not only the ultimate goal of pro-environmental behavior but also its cause as justice functions as a motivator of behavior. To our knowledge, justice sensitivity perspectives have not yet been associated with pro-environmental intention and behavior. Based on the reported findings, the aim of this study is to investigate the extent to which perceptions of injustice predict pro-environmental intention and, in turn, might even predict pro-environmental behavior. More precisely, we assume that the pro-social justice sensitivities (perpetrator, observer, and beneficiary) are positively associated with pro-environmental intention (H1a). The pro-self justice sensitivity (victim) and the tendency to morally disengage are assumed to be negatively associated with pro-environmental intention (H2a). Furthermore, we assume an influence of moral emotions (guilt, shame, authentic and hubristic pride, and gratitude) on pro-environmental intention (H3b).

We also checked whether the three hypotheses also apply for pro-environmental behavior (H1b, H2b, and H3b). However, one must note that pro-environmental intentions might not be implemented in pro-environmental behavior and therefore may not account for all of the variance in pro-environmental behavior. This issue is known as the intention-behavior gap (Sheeran, 2002). If the predictions of Hypotheses 1–3 apply for pro-environmental intention, they might not necessarily apply to pro-environmental behavior.

As guilt results from both high perpetrator and beneficiary sensitivity, and the action tendency of guilt is to correct one's behavior, we assume that guilt mediates the relationship between beneficiary (H4a) and perpetrator (H4b) sensitivity and pro-environmental intention. Moreover, we hypothesize an association between moral disengagement and victim sensitivity (H5). Hypotheses 1-3 can be found in **Figure 1**.

Study 1 was conducted to address Hypotheses 1 (a and b), 2 (a and b), and 5. Albeit the fact that pro-environmental intention cannot be regarded as a promising

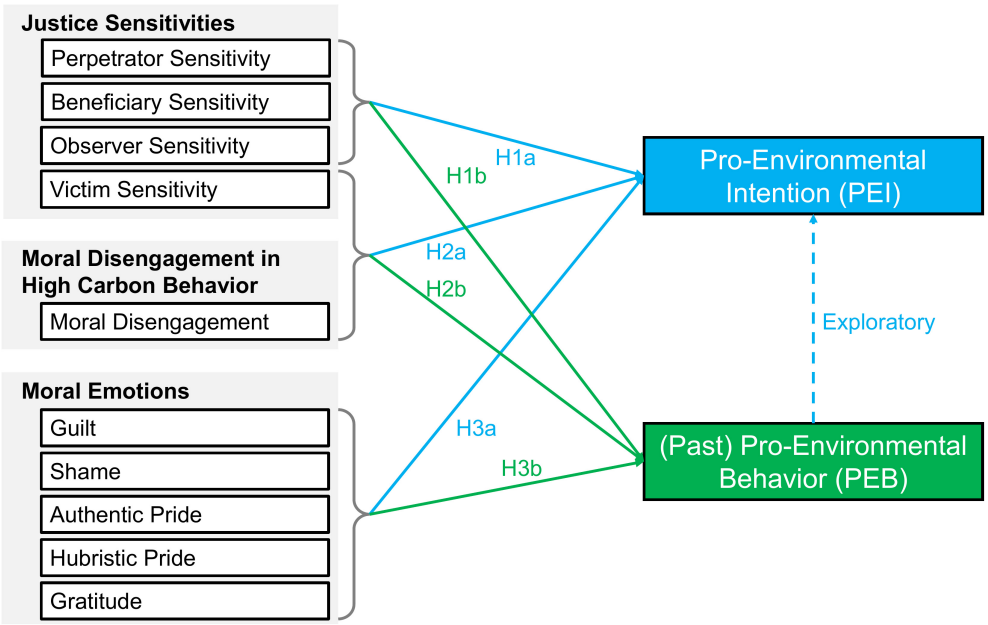

FIGURE 1 | Hypotheses 1–3 (a and b) of the current Study.

predictor for (future) pro-environmental behavior (Sheeran, 2002), past pro-environmental behavior was found to be a strong predictor for pro-environmental intentions (e.g., Bamberg et al., 2003; Carrus et al., 2008; Manca et al., 2020). As pro-environmental behavior was assessed retrospectively (as "past pro-environmental behavior") in Study 1, we also checked if this finding can be replicated with our data (see **Figure 1**).

Study 2 addressed Hypotheses 3 (a and b) and 4 (a and b) and aimed to replicate the findings of Study 1 with a larger sample and a potentially more precise measure of (current) pro-environmental behavior, i.e., the "carbon footprint."

STUDY 1

Materials and Methods

Participants

We recruited 220 German panelists on *meinungsplatz.de*. *Meinungsplatz.de* is a German survey platform offering a pool of 250,000 active participants from all social strata in Germany and Switzerland for market and opinion research purposes. All participants were compensated for their expenses following the policy of the panel service.

Quotas were defined concerning age and gender to ensure representativeness regarding these socio-demographic dimensions. The scheduled age and gender proportions were based on the Federal Statistical Office Germany (2019). Three panelists responded that they were 16 or 17 years old. We initially planned to only include data from participants that were at least 18 years old as these were requested from the panel provider. However, we decided to retain the data from these participants for the analyses as their participation is in accordance with the German legislation and we did not expect their response pattern to differ substantially from the participants that were at least 18 years old. The gender distribution in Germany is nearly equal (50.7% female, 49.3% male; Federal Statistical Office Germany, 2019) and therefore was assumed to be 50:50. Due to an unknown distribution of individuals who identify themselves as non-binary, these were not included (see **Table 1**).

As exclusion criteria, we consulted the relative speed index (RSI; Leiner, 2019) and a social desirability score (Satow, 2012). The RSI is computed by dividing the median page completion time of the sample by the page completion time of the respective individual. A relative speed index of 2 indicates that an individual was twice as fast as the median of the total respondents. According to the recommendation of Leiner (2019), we removed 46 panelists with RSI > 2 as we assumed them to not have worked conscientiously. Additionally, we excluded 12 participants due to socially desirable response tendencies as they scored 7 or higher on the social desirability scale (see Instruments; Satow, 2012).

Therefore, the final sample for Study 1 comprised 174 participants: 91 females and 83 males (age $M = 49.9$, $SD = 17.5$, range = 16–80 years). Two χ^2-tests for goodness of fit for age groups and gender, respectively, found no significant deviation from the proportions set for the recruiting procedure, either for gender, $\chi^2(1) = 0.37$, $p = 0.544$ or for age group, $\chi^2(5) = 2.67$, $p = 0.751$. The resulting sample therefore still represents the distribution of age and gender in the German population as a whole.

Sensitivity analyses using G*Power (Faul et al., 2007) indicated that with the given sample size of $N = 174$, $\alpha = 0.05$, and a power of $1 - \beta = 0.80$, in a linear multiple regression with five predictors (four justice sensitivities, and moral disengagement in high carbon behavior), small effect sizes of $R^2 = 0.071$ and

TABLE 1 | Proportions of German age groups (in 2018) and the derived sampling goals along with the final sample proportions in Study 1.

			Sample after exclusion		
Age group	**Proportion**	**Quota sample before exclusion**	**Female**	**Male**	**Total**
18–25 years	12%	28	10	5	15
26–35 years	15%	34	17	12	29
36–45 years	14%	30	12	12	24
46–55 years	18%	40	16	16	32
56–65 years	16%	36	14	15	29
66 years or older	24%	52	22	23	45

Proportions are based on Federal Statistical Office Germany (2019). We assumed gender to be equally distributed (50:50).

with a power of 1 – β = 0.95 small effect sizes of $R^2 = 0.105$ could be detected.

Instruments

To test our hypotheses, we measured two dependent variables, pro-environmental behavior, and pro-environmental intention. The independent variables were the justice sensitivity perspectives and moral disengagement in high carbon behavior. The descriptive statistics and internal consistency measures of all variables of Study 1 can be found in **Table 2**.

Past Pro-environmental Behavior

To measure the first dependent variable, 10 pro-environmental behaviors were queried for the last year (i.e., 2019 as the survey was conducted in 2020). Due to the pandemic state of emergency during the survey period, we did not ask about the current behavior as this may have been affected by the COVID-19 pandemic. Therefore, we measured past pro-environmental behavior in Study 1. The participants were asked to indicate whether they pursued the specified behavior ("yes," "no," or "do not know"). To prevent an acquiescence bias (the tendency to answer with "yes" regardless of the question), some items were framed pro-environmentally and others from an environmentally damaging perspective. An example of an item is "In 2019, I purchased green electricity." Based on the idea of the Campbell Paradigm (Kaiser et al., 2013), we addressed behaviors of varying "difficulty." For example, we expected it to be more difficult to use green electricity (because it is more expensive) than to lower the washing temperature. The inverted items were subsequently reversed, and the relative frequency of pro-environmental behavior was computed for each person. The internal consistency of the scale was Cronbach's α = 0.41. As the measure can be regarded as a formative measure (the latent construct is formed by the items) instead of a reflective measure (the latent construct is causal for the item responses), internal consistency estimates for reliability coefficients should not be interpreted and not considered for item selection (e.g., Bollen and Lennox, 1991; Rossiter, 2002). The scale can be found in **Appendix A**.

TABLE 2 | Descriptive statistics and internal consistency of all measures in Study 1.

Variable	***M***	***SD***	**Skewness**	**Cronbach's α**
Dependent variables				
Past pro-environmental behavior	0.56	0.83	–0.20	0.41
Pro-environmental intention	4.26	0.18	–0.45	0.67
Independent variables				
Perpetrator sensitivity	2.99	1.34	0.13	0.82
Beneficiary sensitivity	4.97	1.10	–1.11	0.79
Observer sensitivity	4.21	1.17	–0.25	0.68
Victim sensitivity	3.30	1.47	0.14	0.81
Moral disengagement	2.18	1.01	1.14	0.96

Pro-environmental Intention

To measure the second dependent variable, the same 10 items from the past pro-environmental behavior scale were re-formulated as intentions for the following year (i.e., 2021). For example, one item taken from the section above reads: "In 2021, I would like to (continue to) purchase green electricity." As we asked for behavior intentions rather than actual behavior, answers were given on 6-point scales that expressed the participant's approval of the items (ranging from "totally disagree" to "totally agree"). The internal consistency of the scale was Cronbach's α = 0.67. The questionnaire can be found in **Appendix B**.

Justice Sensitivity (USS-8)

The injustice sensitivity scales (USS-8) of Beierlein et al. (2012) measure the four perspectives of justice sensitivity (victim, perpetrator, beneficiary, and observer). Each perspective is measured by two items, answered on a 6-point scale (ranging from "does not apply at all" to "fully applies"). An item example of beneficiary sensitivity is: "I feel guilty when I am undeservedly better off than others." The reliabilities of perpetrator (Cronbach's α = 0.82), beneficiary (Cronbach's α = 0.89), and victim sensitivity (Cronbach's α = 0.81) were good or even excellent; however, the reliability of observer sensitivity was questionable (Cronbach's α = 0.68).

Moral Disengagement in High Carbon Behavior Scale

For Study 1, based on the questionnaire of Moore et al. (2012) on moral disengagement in general, we developed a German questionnaire that measures an individual's propensity to morally disengage in the context of high carbon behavior (MD-HCB; Stoll-Kleemann et al., 2022b). The MD-HCB covers nine mechanisms of moral disengagement following Markowitz and Shariff (2012) and Bandura (2016) with two questions each (18 items in total). An exemplary item is "In terms of my carbon

emissions, I don't want to give much consideration to people who live very far away and whom I will never meet." The reliability was excellent, with Cronbach's α = 0.96, and the measure was found to be valid in terms of factorial, criterion, convergent, and discriminant validity (see Stoll-Kleemann et al., 2022b).

Social Desirability

To detect test falsification due to positive self-presentation and socially desirable response tendencies, the short version of social desirability scale (Satow, 2012) was used. The participants answered two items on a 4-point scale and thus the sum score ranged from 2 to 8. A value of 7 or higher indicated a high tendency to distort self-presentation and it is thus recommended to exclude participants scoring 7 or higher. Based on this criterion, we had to exclude 12 participants prior to the analysis. The final sample consisted of $N = 174$ participants, as described above.

Sociodemographic variables such as gender, age, education level, and working situation were queried directly.

Design and Procedure

We used *SoSci Survey* (Leiner, 2020) to prepare and host the online survey. The questionnaires analyzed in this article were part of a larger data collection comprising further questionnaires on moral constructs (see Stoll-Kleemann et al., 2022b). Starting with the sociodemographic variables, the questionnaires were answered in the following order: moral competence[1], past pro-environmental behavior, moral disengagement in high carbon behavior, pro-environmental intention, moral disengagement in general[1], idealism and relativism[1], justice sensitivity, moral pride[1], empathy and perspective taking[1], moral identity[1], and Machiavellianism[1]. Answering all questions took the participants between 10 and 34 min (*Mdn* = 19 min). The findings were considered significant in two-sided testing when $p < 0.05$. All analyses were conducted using *R* (R Core Team, 2020). In addition to established packages, the following were used: *bda* (Wang, 2021), *car* (Fox and Weisberg, 2019), *dplyr* (Wickham et al., 2022), *skedastic* (Farrar, 2020), and *lm.beta* (Behrendt, 2014).

Results

To test the assumed positive prediction of the pro-social justice sensitivities and the assumed negative prediction of victim sensitivity and moral disengagement according to Hypotheses 1 and 2, we conducted two regression analyses with (a) pro-environmental intention and (b) past pro-environmental behavior as dependent variables, respectively. We included perpetrator, beneficiary, observer, and victim sensitivity as well as moral disengagement in high carbon behavior as predictors (Model A: on pro-environmental intention, Model B: on past pro-environmental behavior).

The prerequisites of no autocorrelation and normal distribution of residuals were given in both models. Model A showed multicollinearity, and Models A and B heteroscedasticity. As a linear model can be considered robust (Cohen, 2013), it was nevertheless used in this study. The regression tables of Models A and B are provided in **Table 3**.

Model A significantly predicted pro-environmental intention, $F(5, 168) = 20.08$, $p < 0.001$, with a large effect size (according to Cohen, 2013), $R^2 = 0.37$ (adjusted $R^2 = 0.36$). Observer sensitivity (positive) and moral disengagement (negative) were significant predictors. All effects were in the hypothesized direction and, therefore, Hypotheses 1a and 2a were partially supported.

Model B predicted past pro-environmental behavior significantly, $F(5, 168) = 7.46$, $p < 0.001$, with $R^2 = 0.18$ (adjusted $R^2 = 0.16$), which is indicative of a medium effect size (Cohen, 2013). The only significant predictor was moral disengagement (negative). Except for beneficiary sensitivity, the effects were at least in the hypothesized direction, although they were not significant. As a result, Hypothesis 2b received only partial support.

Additionally, as past behavior was shown to be a strong predictor of pro-environmental intention (e.g., Bamberg et al., 2003; Carrus et al., 2008; Manca et al., 2020), we exploratively added past pro-environmental behavior in a second step in the regression analysis on pro-environmental intention. The standardized regression weights are shown in **Table 3**. Together, the predictors of this model (justice sensitivities, moral disengagement, past pro-environmental behavior) significantly predicted pro-environmental intention, $F(6, 167) = 66.78$, $p < 0.001$, with a large effect size (Cohen, 2013), $R^2 = 0.71$ (adjusted $R^2 = 0.70$). Adding past behavior as a predictor explained an additional 33% of the variance of pro-environmental intention, incremental $F(1, 167) = 188.35$, $p < 0.001$. While, perpetrator, beneficiary, and victim sensitivity remained non-significant predictors, moral disengagement in high carbon behavior was still significant. Observer sensitivity no longer significantly predicted pro-environmental intention. Past behavior was not only a significant, but also the strongest predictor in this model, followed closely by moral disengagement. Moreover, the inclusion of past behavior also reduced the explanatory power of moral disengagement.

In line with Hypothesis 5, moral disengagement in high carbon behavior was positively correlated to victim sensitivity, $r(172) = 0.21$, $p = 0.005$. As both variables were not normally distributed, Spearman's rank correlation was additionally computed. This supported the result obtained with the Pearson correlation, $\rho = 0.12$, $p < 0.001$.

STUDY 2

To replicate the findings of Study 1 (H1, 2, and 4) in a larger sample and to additionally test Hypotheses 3 and 5, we again measured the two dependent variables pro-environmental behavior and pro-environmental intention. However, to provide a potentially more accurate measure for environmentally friendly behavior, we used a carbon footprint calculator in Study 2. The independent variables again were the justice sensitivity perspectives and moral disengagement in high carbon behavior. We included moral emotions as predictors and guilt as a mediator.

[1]These questionnaires are not the subject of this article.

TABLE 3 | Regression analyses of pro-environmental intention and past pro-environmental behavior on justice sensitivity and moral disengagement in high carbon behavior in Study 1.

	Model A: Pro-environmental intention			Model B: Past behavior		
Effect	**β**	**95% CI [LL, UL]**	***p***	**β**	**95% CI [LL, UL]**	***p***
Confirmatory analysis						
Perpetrator sensitivity	0.02	[–0.12, 0.15]	0.793	0.08	[–0.07, 0.34]	0.295
Beneficiary sensitivity	0.04	[–0.09, 0.17]	0.532	–0.03	[–0.19, 0.13]	0.702
Observer sensitivity	**0.16**	**[–0.01, 0.31]**	**0.033**	0.16	[–0.01, 0.33]	0.058
Victim sensitivity	–0.08	[–0.22, 0.06]	0.266	–0.14	[–0.31, 0.02]	0.083
Moral disengagement	**–0.52**	**[–0.66, –0.39]**	**< 0.001**	**–0.33**	**[–0.49, –0.17]**	**< 0.001**
Exploratory analysis						
Perpetrator sensitivity	–0.03	[–0.13, 0.08]	0.468			
Beneficiary sensitivity	0.06	[–0.03, 0.16]	0.190			
Observer sensitivity	0.06	[–0.05, 0.16]	0.274			
Victim sensitivity	0.01	[–0.09, 0.11]	0.825			
Moral disengagement	**–0.31**	**[–0.41, –0.21]**	**< 0.001**			
Past behavior	**0.64**	**[0.55, 0.73]**	**< 0.001**			

Model A: $F(5, 168) = 20.08$, $p < 0.001$, $R^2 = 0.37$; Explorative Analysis: $F(6, 167) = 66.78$, $p < 0.001$, $R^2 = 0.71$; Model B: $F(5, 168) = 7.46$, $p < 0.001$, $R^2 = 0.18$. β = standardized regression weights. LL and UL indicate the lower and upper limits of a confidence interval of the standardized regression weights, respectively. Bold values indicate significant results.

Materials and Methods

Participants

For the second study, we recruited 1,100 German participants in parallel to Study 1 (*via meinungsplatz.de*). Parallel quota ratios regarding the distribution of the German population for gender and age were set. We also applied the same exclusion criteria as in Study 1. Consequently, $n = 121$ participants were excluded due to the RSI (Leiner, 2019), and $n = 99$ due to potential socially desirable responses (Satow, 2012).

The final sample of Study 2 comprised 880 participants with 454 females and 426 males (age $M = 50.43$, $SD = 17.0$, range = 18–84 years). Two χ^2-tests checked whether the age and gender groups of the reduced sample were still in line with the predefined quotas. We found no significant deviation from the proportions set for the recruiting procedure, either for gender, $\chi^2(1) = 0.89$, $p = 0.345$ or for age group, $\chi^2(5) = 9.00$, $p = 0.109$. Therefore, the final sample can still be regarded as representative of the German adult population in terms of age and gender (also see **Table 4**).

A sensitivity analysis using G*Power (Faul et al., 2007) indicated that with the given sample size of $N = 880$, $\alpha = 0.05$, and a power of $1 - \beta = 0.80$, linear multiple regression with 10 predictors (four justice sensitivities, moral disengagement in high carbon behavior, guilt, shame, authentic and hubristic pride, gratitude) could detect small effect sizes of $R^2 = 0.02$ and with a power of $1 - \beta = 0.95$ could detect small effect sizes of $R^2 = 0.03$. As these effect sizes are even smaller than those we found in Study 1, the sample size can be regarded as being sufficient to reliably quantify the effects.

Instruments

For pro-environmental intention, justice sensitivity, moral disengagement in high carbon behavior, and sociodemographic data, the same instruments from Study 1 were used. However, we exchanged the instrument for pro-environmental behavior and included scales for moral emotions. The descriptive statistics and internal consistencies of all variables of Study 2 can be found in **Table 5**.

Pro-environmental Behavior (Carbon Footprint)

To obtain a more informative proxy measure of pro-environmental behavior, participants calculated their current individual carbon footprint with a carbon footprint calculator developed by the German Environment Agency (Umweltbundesamt [UBA], 2022). The calculator was embedded into the survey so that there was no need to leave the website. The questions covered the domains (1) living and electricity, (2) mobility, (3) diet, (4) other consumer behavior, and (5) public emissions. The participants had to complete forms asking for specific details of their daily life, e.g., personal annual mileage with one's own car, via carsharing, bicycling, and public transport or whether they forgo the purchase of new products in favor of second-hand goods.

Pride, Guilt, and Shame-Proneness

In the lack of soundly validated *and* economic, i.e., brief, German scales to measure pride, guilt, and shame proneness, we designed four scenarios based on the Test of Self-Conscious Affect (TOSCA; Tangney et al., 2000) – two in which an intended pro-environmental behavior was (a) accomplished or (b) not accomplished, respectively. An example of such a scenario is the following: "For ecological reasons, you have decided to travel less by car and more by bicycle. Accordingly, you have planned to ride your bike the short distance to visit someone in the evening. However, when the time comes, you feel exhausted and take the car again." Participants rated statements such as: "You would regret taking the car" (guilt-proneness), on a 6-point scale (1 = not likely, 6 = very likely). Thus, guilt, shame, and authentic and hubristic pride were each assessed with 2 items in 2 different scenarios, resulting in 8 items; and each scenario measured two emotions (shame and guilt, or authentic and hubristic pride). The original questionnaire was developed on the

TABLE 4 | Proportions of German age groups (in 2018) and the derived sampling goals along with the final sample proportions in Study 2.

			Sampling after exclusion		
Age group	**Proportion in population**	**Quota sampling before exclusion**	**Female**	**Male**	**Total**
18–25 years	12%	136	53	39	92
26–35 years	15%	166	65	55	120
36–45 years	14%	154	57	54	111
46–55 years	18%	200	87	82	169
56–65 years	16%	182	76	83	159
66 years or older	24%	262	116	113	229

Proportions are based on Federal Statistical Office Germany (2019). We assumed gender to be equally distributed (50:50).

TABLE 5 | Descriptive statistics and internal consistency of all focal measures in Study 2.

Variable	***M***	***SD***	**Skewness**	**Cronbach's α**
Dependent variables				
Pro-environmental behavior	11.12	8.04	14.81	–
Pro-environmental intention	4.20	0.67	−0.37	0.66
Justice sensitivities				
Perpetrator sensitivity	4.61	1.31	−0.90	0.87
Beneficiary sensitivity	3.00	1.34	0.17	0.88
Observer sensitivity	4.25	1.20	−0.69	0.79
Victim sensitivity	3.52	1.39	−0.14	0.81
Moral disengagement	2.40	1.01	0.58	0.95
Moral emotions				
Guilt proneness	3.52	1.50	−0.15	0.66
Shame proneness	3.60	1.52	−0.23	0.67
Authentic pride	4.52	1.17	−0.82	0.55
Hubristic pride	4.56	1.17	−0.82	0.54
Thankfulness	4.43	1.32	−0.72	0.78

Cronbach's α contains standardized internal consistencies.

basis of descriptions of personal experiences of guilt, shame, and pride, and was found to successfully measure characteristic guilt- and shame-proneness as well as authentic and hubristic pride. The internal consistency was questionable for guilt (α = 0.66) and shame (α = 0.67) and poor for both dimensions of pride ($\alpha_{\text{authentic pride}} = 0.55$, $\alpha_{\text{hubristic pride}} = 0.54$). However, as the scales comprise only two items and these items were presented in the context of different scenarios which might have introduced a context variance, the reliabilities were regarded as acceptable and, therefore, sufficient for the planned analyses; the scenarios and items can be found in **Appendix C**.

Gratitude-Proneness in Climate Change

We asked the participants whether they are thankful for their privileges in the climate crisis (6-point scale; 1 = "totally disagree", 6 = "totally agree"). The two items were: "I am grateful to live in a region of the world where climate change will arrive later and less extreme than in other regions" and "I am grateful to belong to a generation that is even less affected by climate change than future generations." Cronbach's α was acceptable (0.78). The items can also be found in **Appendix C**.

Design and Procedure

Again, we conducted an online survey with the help of *SoSci Survey* (Leiner, 2020). The time required to answer all questions ranged from 9.8 to 68.1 min, with 25.1 min being the median. The findings were considered significant in two-sided testing when $p < 0.05$. All analyses were conducted using *R* (R Core Team, 2020) using the same packages from Study 1.

Results

According to Hypotheses 1 and 2, we again assumed a positive prediction of the pro-social justice sensitivities and a negative prediction of the pro-self sensitivity and moral disengagement. Additionally, we investigated Hypothesis 3 which stated that there is an association between moral emotions and pro-environmental behavior and intention. All three hypotheses were tested by calculating multiple regression analyses on (a) pro-environmental intention and (b) pro-environmental behavior. The prerequisites of no autocorrelation and multicollinearity were given for both regression models on pro-environmental behavior and pro-environmental intention. Homoskedasticity was given for Model B (pro-environmental behavior), but not for Model A (pro-environmental intention), and normal distribution of residuals was not given in both models. As a regression analysis can be considered robust (Cohen, 2013), it was nevertheless used in this study.

When testing Hypotheses 1a, 2a, and 3a, the model comprising justice sensitivities, moral emotions, and moral disengagement significantly predicted pro-environmental intention (Model A), $F(10, 869) = 38.27$, $p < 0.001$, $R^2 = 0.31$ (adjusted

R^2 = 0.30), whereby significant predictors were perpetrator and beneficiary sensitivity, moral disengagement, and authentic pride. However, observer and victim sensitivity, guilt, shame, hubristic pride, and gratitude were non-significant (see **Table 6** for regression weights).

A multiple regression model comprising the justice sensitivities, moral emotions, and moral disengagement in high carbon behavior failed to significantly predict pro-environmental behavior (Model B), $F(10, 869) = 1.36$, $p = 0.197$. **Table 6** shows the regression weights of all predictors. Contrary to expectations, moral disengagement was shown to be the only significant predictor whereas perpetrator, beneficiary, observer, and victim sensitivity, guilt, shame, authentic and hubristic pride, and gratitude were non-significant predictors. Hence, Hypotheses 1b, 2b, and 3b were not supported.

To reduce our comparably complex model on pro-environmental intention, a stepwise regression analysis with statistical backward elimination (based on AIC) was conducted to identify the relevant predictors. According to a backward-elimination strategy, victim sensitivity, shame proneness, and gratitude were excluded from the final regression model ($p > 0.252$). This final model (Model A-) can be found in **Table 7** as well as in **Figure 2**. Consequently, the final model included the following predictors: perpetrator, beneficiary, and observer sensitivity, moral disengagement in high carbon behavior, guilt-proneness, and authentic and hubristic pride. This final model significantly predicted pro-environmental intention, $F(7, 872) = 54.41$, $p < 0.001$, with a large effect size, $R^2 = 0.30$ (adjusted $R^2 = 0.29$).

A mediation analysis in line with Baron and Kenny (1986) was performed to test Hypothesis 4a, i.e., whether the prediction of beneficiary sensitivity for pro-environmental intention would be mediated by guilt-proneness. In step 1 of the mediation model, the regression of pro-environmental intention on beneficiary sensitivity, ignoring the mediator, was significant, $\beta = 0.12$, $p < 0.001$. Step 2 showed that the regression of the mediator (guilt) on beneficiary sensitivity was also significant, $\beta = 0.31$, $p < 0.001$. Step 3 of the mediation analysis showed that the mediator (guilt), controlling for beneficiary sensitivity, significantly predicted pro-environmental intention, $\beta = 0.34$, $p < 0.001$. Step 4 of the analysis revealed that controlling for the mediator (guilt), beneficiary sensitivity was not a significant predictor of pro-environmental intention, $\beta = 0.01$, $p = 0.708$. According to a Sobel test ($z = 7.06$, $p < 0.001$), guilt fully mediated the relationship between beneficiary sensitivity and pro-environmental intention. This mediation is illustrated in **Figure 3**.

A second mediation with the same procedure (Baron and Kenny, 1986) was performed to analyze whether perpetrator sensitivity predicts pro-environmental intention and whether the direct path would be mediated by guilt (Hypothesis 4b). In step 1 of the mediation model, the regression of pro-environmental intention on perpetrator sensitivity, ignoring the mediator, was significant, $\beta = 0.30$, $p < 0.001$. Step 2 showed that the regression of the mediator (guilt) on perpetrator sensitivity was also significant, $\beta = 0.25$, $p < 0.001$. Step 3 of the mediation analysis showed that the mediator (guilt), controlling for perpetrator sensitivity, significantly predicted pro-environmental intention, $\beta = 0.29$, $p < 0.001$. Step 4 of the analysis revealed that controlling for the mediator (guilt), the predictive power of beneficiary sensitivity on pro-environmental intention was reduced, $\beta = 0.23$, $p \leq 0.001$. Again, a Sobel Test showed that this mediation is significant ($z = 5.81$, $p < 0.001$). Therefore, guilt partially mediated the relationship between perpetrator sensitivity and pro-environmental intention. The second mediation analysis is also illustrated in **Figure 3**.

Confirming Hypothesis 5, victim sensitivity was again positively and significantly correlated with moral disengagement in high carbon behavior, $r(878) = 0.13$, $p < 0.001$. As both variables were not normally distributed, Spearman's rank correlation was again computed which returned the same result, $\rho = 0.14$, $p < 0.001$.

DISCUSSION

The aim of this study was to investigate the role of justice sensitivity, moral disengagement, and moral emotions on pro-environmental intention and behavior. In Study 1, moral disengagement in high carbon behavior was able to significantly and negatively predict past pro-environmental behavior, while the four justice sensitivities did not. A pro-environmental intention was significantly predicted by moral disengagement in high carbon behavior (negatively) and observer sensitivity (positively). Therefore, Hypotheses 1 and 2 were only partially supported. An attempt to replicate these results in a larger sample (Study 2) with the exact carbon footprint calculator as a proxy for pro-environmental behavior failed. However, the pro-environmental *intention* was significantly predicted in the larger sample by justice sensitivities, moral disengagement, and moral emotions. In the final model, after a backward elimination process, perpetrator sensitivity, guilt, and hubristic pride emerged as significant positive predictors and beneficiary sensitivity and moral disengagement as significant negative predictors. Victim sensitivity, shame, and gratitude were excluded because their explanatory power was too low compared to the other predictors. Consequently, Hypothesis 3 was only partially supported. Based on the results, lower moral disengagement served as the best predictor for (more) pro-environmental intention and behavior in both studies. However, an exploratory analysis in Study 1 showed that past behavior was an even stronger predictor of pro-environmental intention. Whereas beneficiary sensitivity was a significant negative predictor in the final model on pro-environmental intention (Model B), its direct effect on pro-environmental intention in the mediation analysis was positive, as hypothesized. In line with Hypothesis 4, the predictions of perpetrator and beneficiary sensitivity were mediated by guilt, which is the emotion that occurs at high levels in each of these two justice sensitivities.

In the light of these findings and the cognitive appraisal theory of emotions (Arnold, 1960), we support Baumert et al. (2013b) explanation that the perception of injustice (here: beneficiary and perpetrator sensitivity) elicits moral emotions (here: guilt), which in turn lead to an action tendency (here: pro-environmental

TABLE 6 | Regression analyses of pro-environmental intention and behavior *via* justice sensitivity, moral disengagement in high carbon behavior, and moral emotion in Study 2.

	Model A: Pro-environmental intention			Model B: Pro-environmental behavior		
Effect	β	95% CI [LL, UL]	*p*	β	95% CI [LL, UL]	*p*
Perpetrator sensitivity	**0.12**	**[0.06, 0.19]**	**< 0.001**	0.06	[–0.02, 0.14]	0.145
Beneficiary sensitivity	**–0.08**	**[–0.15, –0.01]**	**0.018**	**–0.08**	**[–0.16, 0.16]**	**0.050**
Observer sensitivity	0.06	[–0.01, 0.13]	0.100	0.02	[–0.07, 0.10]	0.725
Victim sensitivity	–0.02	[–0.08, 0.04]	0.576	< 0.01	[–0.07, 0.07]	0.998
Moral disengagement	**–0.30**	**[-0.37, –0.23]**	**< 0.001**	**0.82**	**[0.02, 0.18]**	**0.011**
Guilt	0.06	[–0.05, 0.16]	0.301	0.01	[–0.11, 0.14]	0.830
Shame	0.04	[–0.07, 0.14]	0.498	–0.03	[–0.16, 0.10]	0.643
Authentic Pride	**0.14**	**[0.04, 0.24]**	**0.007**	–0.03	[–0.15, 0.10]	0.677
Hubristic Pride	0.09	[–0.01, 0.02]	0.079	0.05	[–0.08, 0.17]	0.462
Gratitude	–0.03	[–0.09, 0.02]	0.253	< 0.01	[–0.07, 0.07]	0.993

Model A: $F(10, 869) = 38.27$, $p < 0.001$, $R^2 = 0.30$; Model B: $F(10, 869) = 1.36$, $p = 0.197$, $R^2 = 0.02$. β = standardized regression weights. LL and UL indicate the lower and upper limits of a confidence interval of the standardized regression weights, respectively. In Study 2, higher scores in pro-environmental behavior indicate a higher carbon footprint. Predictors should be interpreted in line with this. Bold values indicate significant results.

intention). This theoretical model should be considered for further research on the role of justice sensitivity and moral emotions on pro-environmental intention and may be included in models of pro-environmental behavior.

Consistent with Hypothesis 5, victim sensitivity was positively related to moral disengagement, which is a strong negative predictor of pro-environmental behavior and intention in our study. Individuals with high victim sensitivity thus are more prone to morally disengage and justify their actions instead of taking responsibility. As we outlined in the Introduction, pro-environmental behavior requires accepting responsibility. We regard taking responsibility and moral disengagement as opposites, especially in the area of pro-environmental intention and behavior. Detert et al. (2008) found factors that inhibit or facilitate moral disengagement. While empathy, perspective-taking, moral identity, female gender, and an internal locus of control were found to be inhibitors of moral disengagement, trait cynicism and an external locus of control were found to facilitate moral disengagement. According to our findings, victim sensitivity can be added to the list of facilitators. Therefore, people with high victim sensitivity, who rather tend to morally disengage than to take responsibility are the brakemen of socio-ecological transformation, as they are not willing to act for the sake of the common good but only for their own benefit. The twisted part is that these people see themselves as victims. They argue, for example, that something is taken away from them or that they are disadvantaged. This can be observed in various social debates as the following two examples show: First, in Germany, members of the right-wing populist party Alternative für Deutschland (AfD) have been portraying themselves as victims of political correctness for years as a political strategy (Heinze, 2021). Second, deniers of the COVID-19 pandemic reinforce this perception by wearing a Jewish badge (historic symbol of discrimination, originally used to discriminate Jewish people in Nazi-Germany) with the inscription "unvaccinated" (Fröhlich, 2022). What is striking here is the general pattern of using self-staging as a victim as a political strategy in radical right-wing movements (Weiß, 2011), which in turn increasingly attracts victim sensitives. A current study by Jahnke et al. (2020) provides empirical evidence that victim sensitivity predicted stronger right-wing orientations as well as general and right-wing radicalization.

Although not all justice sensitivities significantly predicted pro-environmental behavior and pro-environmental intention in all models, most of our hypotheses were supported. The considered constructs performed better at predicting pro-environmental intention than behavior and past behavior. This could be due to the intention-behavior gap, which describes that intended behavior is not always implemented (Sheeran, 2002). It is conceivable that the constructs used here refer only to intention, but not to implementation. Also, we may have included too many and too similar predictors. Although multicollinearity was absent (except for Model A in Study 1), perpetrator, beneficiary, and observer sensitivity showed high concordance in previous studies (Münscher, 2017).

TABLE 7 | Regression model of pro-environmental intention after backward elimination of Model A.

	Model A		
Effect	β	95% CI [LL, UL]	*p*
Perpetrator sensitivity	**0.12**	**[0.06, 0.19]**	**< 0.001**
Beneficiary sensitivity	**–0.08**	**[–0.15, –0.01]**	**0.017**
Observer sensitivity	0.05	[–0.01, 0.12]	0.121
Moral disengagement	**–0.31**	**[–0.37, –0.24]**	**< 0.001**
Guilt	**0.09**	**[0.02, 0.15]**	**0.013**
Authentic pride	**0.14**	**[0.03, 0.24]**	**0.010**
Hubristic pride	0.09	[–0.01, 0.19]	0.082

$F(7, 872) = 54.41$, $p < 0.001$, $R^2 = 0.30$. β = standardized regression weights. LL and UL indicate the lower and upper limits of a confidence interval of the standardized regression weights, respectively. Bold values indicate significant results.

Therefore, some authors (e.g., Jahnke et al., 2020) use only one pro-social justice sensitivity. Another approach could be to aggregate these measures (e.g., by means of factor scores) into an umbrella score for pro-social sensitivities. We further assume that the high predictive power of moral disengagement undermines the prediction of the justice sensitivities, especially the similar effect of victim sensitivity. However, moral disengagement in high carbon behavior and victim sensitivity were correlated but not as high as they would reflect an overarching construct. Although any association with pro-environmental *behavior* was weak in both studies (which also means in the two different scales that were used), we found that victim sensitivity and moral disengagement negatively predicted pro-environmental *intention*, while perpetrator, beneficiary, and observer sensitivity positively predicted pro-environmental intention. This may be explained by different degrees of responsibility taking: Those who perceive injustice from the perspective of the beneficiary, observer, or perpetrator are more likely to feel responsible (Ehrhardt-Madapathi et al., 2018). A greater sense of responsibility, in turn, is a promising predictor to engage in pro-environmental behavior (Kollmuss and Agyeman, 2002).

Given these diametrical effects of pro-social and pro-self sensitivities, it seems promising to investigate whether the pro-social perspectives of justice sensitivity can be trained and increased. A preliminary study in this area (Maltese et al., 2013) shows that specific training can teach people to recognize the consequences of their behavior as being unjust in ambiguous situations. In a subsequent game, this classification led people to use more of their own resources to restore justice, in contrast to the control group. Applied to the context of the climate crisis, the aim would be to draw attention to why the climate crisis is a matter of justice and how one's own behavior is connected to the unjust consequences of the climate crisis. Another example is the intervention of Malan et al. (2020) who were able to motivate university students to reduce their high carbon-emitting meat consumption by highlighting the impacts on social justice (and environmental sustainability).

One may argue that a focus on the consequences of individual behavior may lead to reactance, as the resulting emotion of perpetrator and beneficiary sensitivity is guilt, and people seek to protect themselves from negative emotions. Indeed, in our study, moral disengagement in high carbon behavior had remarkable predictive power. According to the theory of moral disengagement (Bandura, 2016), emotional distress (an aversive negative affective state) is unpleasant to endure. As a result, individuals rather change their argumentation (via justifications) than their behavior. Therefore, a focus on negative emotions may lead to increasing moral disengagement instead of a behavioral change. That is why Chapman et al. (2017) recommended that a nuanced and authentic approach is necessary when emotions are used to target pro-environmental behavior change. However, we state that outlining means of behavior change, rather than just pointing out what is being done wrong, induces anticipated pride. Both authentic and hubristic pride withstood a backward elimination as predictors of pro-environmental intention, and, therefore, should be considered in attempts to change behavior. This is also in line with the literature on the positive effects of pride on pro-environmental behavior (Bissing-Olson et al., 2016). Notwithstanding, the effect of pride is not consistent but rather depends on the context (Hurst and Sintov, 2022), which again supports the necessity of careful use of emotions in pro-environmental behavior change.

However, another positive emotion relevant for pro-environmental behavior and intention which we included in our study, namely gratitude, was undermined by the backward elimination procedure and thus its effect on pro-environmental behavior can be assumed to be small in comparison to justice sensitivity, moral disengagement, guilt, and pride. As we outlined in the Introduction, we expected gratitude for privileges to be a generalized emotion shaping behavior (Landmann, 2020). Currently, there is not much literature on the role of gratitude in pro-environmental behavior. Yet, this finding potentially challenges a recent finding on the positive effect of gratitude on pro-environmental intention (Tam, 2022). This may be rooted in Tam's concept of gratitude, which can also be regarded as a trait but directly refers to gratitude toward nature rather than one's own privileges in the face of climate injustice. Gratitude toward nature is similar to and associated with connectedness to nature, which also is a positive predictor of pro-environmental behavior (Kals and Maes, 2002; Tam, 2022). Contrary to gratitude toward nature, gratitude toward one's own privileges requires a high level of reflectiveness as one has to not take comfortable benefits for granted (e.g., mobile devices whose batteries are manufactured under exploitative working conditions and water pollution; Wanger, 2011).

This ability to recognize one's own privileges, however, may also lead to existential guilt instead of gratitude toward privileges. Existential guilt describes the moral emotion of a person who benefits from illegitimate privileges and occurs in individuals who causally link their own privileges to others' deprivation, and can see their advantages as the results of a circumstance that they are able to control (Montada et al., 1986). It mainly arises in individuals with a high beneficiary sensitivity (Gollwitzer et al., 2005). In the current study, guilt proneness was positively predicted by both, beneficiary and perpetrator sensitivity.

The positive prediction of pro-environmental intention by guilt stands in line with existing literature (Carrus et al., 2008; Rees et al., 2014; Hurst and Sintov, 2022). However, in our study, guilt was not only a significant predictor but also a mediator. We, therefore, recommend devoting more attention to different theoretical and statistical associations than simple predictions. The data of our study suggest that the predictive power of shame was comparably small which is consistent with the results of an experimental study by Rees et al. (2014) who showed that the combination of guilt and shame into a "guilty conscience" construct was a stronger predictor of pro-environmental behavior than each of them taken separately. However, in their study, it was shame and not guilt that transformed the intention into manifest behavior. Consequently, shame may play a role in the implementation of pro-environmental intentions. Yet, the body of literature on

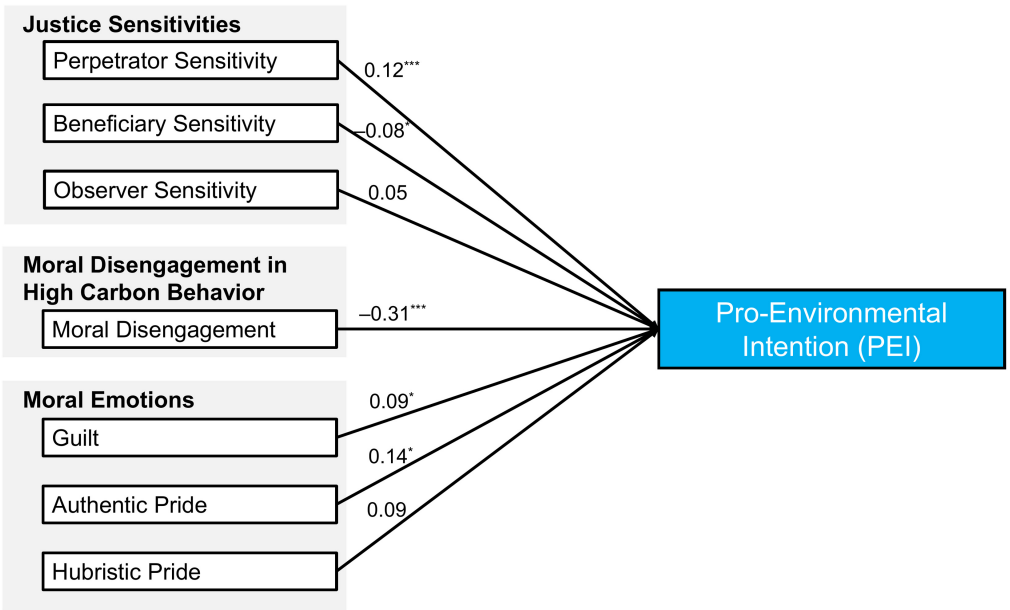

FIGURE 2 | Regression weights of the final model of pro-environmental intention after backward elimination. This final model significantly predicted pro-environmental intention, $F(7, 872) = 54.41$, $p < 0.001$, with a large effect size, $R^2 = 0.30$ (adjusted $R^2 = 0.29$). $^*p < 0.05$, $^{***}p < 0.001$; coefficients are standardized regression weights.

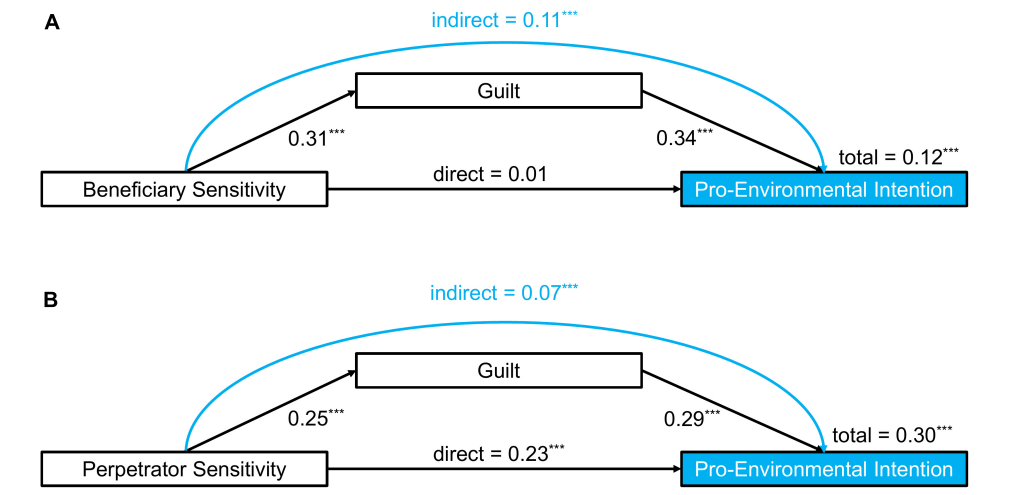

FIGURE 3 | Mediation analyses of guilt on the effect of **(A)** Beneficiary sensitivity [respectively **(B)** Perpetrator sensitivity] on pro-environmental intention. $^{***}p < 0.001$; coefficients are standardized regression weights.

shame is not as abundant as is on guilt; therefore, it is difficult to compare their respective influences.

The approach of combining emotions, as Rees et al. (2014) presented, nevertheless seems to be promising. When considering emotions, it is important to note that they rarely occur in isolation, but often as a blend. A current qualitative study (Marczak et al., 2022) shows that the emotional landscape concerning climate change is not limited to categories like, e.g., "anger," but rather includes various specific emotions such as exasperation, irritation, frustration, impatience, annoyance, disgust, anger, and rage, as these are related to a perceived lack of commitment to climate action (these are only the emotions in the area of "anger"). A quantitative study (Stanley et al., 2021) confirmed that feeling each of three common climate emotions, fear, anger, and sadness, was a strong predictor of also experiencing the other two and hence the role of emotions under realistic conditions and not just in isolation from other emotions should be investigated. In line with this, Chapman et al. (2017) criticized the current research for overemphasizing the role of single emotions and, as a result, more studies investigated

emotional profiles instead of single emotions in the context of the environment. Fernando et al. (2014) found, e.g., that sympathy for specific groups of people alone hardly produces intentions to act, but instead requires a (pro-social) emotional profile of sufficient sympathy, shame, and anger at the government and one's ingroup, as well as some anger about those affected and some pride. Another example is the study of Wang et al. (2018), who found an emotional profile that was associated with high acceptance of environmental protection measures. This profile consisted of higher values for anger, anxiety, guilt, shame, powerlessness, and desperation (called the self-blame profile). Therefore, addressing emotions as patterns rather than single individual phenomena seems promising to consider in further investigations on pro-environmental behavior and intention.

Given the predictive power of guilt, and authentic pride, we agree with Landmann (2020) that addressing (already existing) generalized emotions may be more effective than single (induced) emotional episodes. We assume the proneness or dispositional tendency to experience a specific type of emotion to play a key role in motivating pro-environmental behavior. Being used in such a way, emotion research can help to better understand the psychological processes in pro-environmental intention and behavior. Roeser (2012) confirms that emotions may help to see something that purely rational assessments fail to discover. In her study, information about climate change with emotional content provided better insight into its moral meaning, while also providing a deeper, more reliable source of motivation for action than information without emotional content. Consequently, especially in the domain of the psychology of justice and morality, emotions are central and should receive more attention from environmental psychologists.

Limitations

This study has some limitations concerning (1) the design, (2) the instruments, and (3) the sample. First of all, we used a correlational design which is not suitable for conclusions on causal relations between variables. Further research may expand our study design and derive more suitable experimental designs. Additionally, we only gave one possible order of the questionnaires involved in this study. However, having previously presented a scale such as moral disengagement in high carbon behavior might have influenced the subsequent scales such as pro-environmental intention. Since moral disengagement is used as a justification for not behaving in a pro-environmental manner, responses on the pro-environmental intention scale might have been lower than if the moral disengagement scale had been administered subsequently. However, we wanted pro-environmental intention to be answered not directly after pro-environmental behavior as we hypothesized this would cause the participants to repeat their answers from pro-environmental behavior instead of actually elaborating on their pro-environmental intention. Furthermore, some other emotions that are associated with justice sensitivity (e.g., anger, or moral outrage) could be included in further investigations. Also, as mentioned before, qualitative approaches seem promising to get a broader insight into the emotional landscape in the context of climate justice. Second, questionnaires are based on self-reported behavior, which may introduce biased responses. To counteract this, we followed the recommendations of Satow (2012) and used a measure to exclude the data from socially desirable responding individuals. Due to the lack of an appropriate measure, we established a measure of the proneness to various emotions in the climate context for this study (see Methods). However, this measure was not validated. Also, the use of the carbon footprint calculator from Study 2 requires a lot of time and asks for very detailed information which may frustrate participants and lead them to not fill in the questionnaire conscientiously or even refrain from completing it at all. Additionally, standard answers are set in the carbon footprint calculator which may influence the answers of the participants. Third, our objective was to acquire a representative sample which is why we aimed to get a large sample size in Study 2. However, considering the high power of our calculations, we may have "oversampled" this second sample. A sample size that is that large may lead to an increased Type I error. At the same time, effect sizes, which we also used, are smaller in larger samples and account for this. Additionally, as we used the platform *meinungsplatz.de* to recruit panelists, the participants may be more affine toward digital media than other social groups as they created an account on that platform.

CONCLUSION

We showed that pro-social justice sensitivities are able to (at least partially) predict pro-environmental behavior and intention. In our study, guilt mediated the relationship between justice sensitivity and pro-environmental intention. Authentic pride was also found to be a significant predictor of pro-environmental intention. Moral disengagement in high carbon behavior turned out to be a barrier to pro-environmental behavior change and is associated with dispositional victim sensitivity.

Consequently, we recommend rendering the aspects of justice, e.g., the consequences for the most vulnerable people, in climate change more saliently—both in future research interventions and climate communication by political agents or the media. The current Intergovernmental Panel on Climate Change [IPCC] (2022) started off strongly by consistently demanding more equitable societies. With great confidence, the authors thus declare that "solutions based on equity and social and climate justice reduce risks and enable climate resilient development" (p. 31). Climate justice is not only the ultimate goal of pro-environmental behavior, but it can also function as its elicitor by being a fundamental human motive that triggers strong moral emotions.

However, the realization of being a beneficiary of an unjust *status quo* can also be challenging and may elicit negative emotions. These negative emotions can lead to moral disengagement, especially when individuals score high in victim sensitivity. Therefore, the challenge when highlighting privilege is to ensure that the target group is supported when feeling negative emotions so that it does not slip into moral disengagement. For people who are already highly victim-sensitive, specific strategies should be designed that can liberate them from their suspicion and fear of experiencing a disadvantage.

Making the injustice of climate change more salient may thus be the first step toward achieving more climate-just societies.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Both studies were designed and conducted in accordance with the Code of Ethics of the World Medical Association (2013) ("World Medical Association Declaration of Helsinki"). The participants in the two studies gave their informed consent to participate prior to the start of the survey. Ethical review and approval were not required for these studies in accordance with the German legislation and with institutional requirements. The consent of the data protection officer of the University of Greifswald has been obtained. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SN conceived of the presented idea and wrote the first draft. SN, PF, and SS-K contributed to conception and design of the study. PF organized the database. SN and PF performed the statistical analysis. All authors contributed to manuscript revision, read, and approved the submitted version.

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APPENDIX

Appendix A

Questionnaire on past pro-environmental behavior. Participants answered "yes," "no," or "do not know." (R) indicates inversed items.

To what extent do these statements apply to you?

- In 2019, I mainly used a car for short distances (up to 20 km). (R)
- In 2019, I took trips by plane. (R)
- In 2019, I ate a vegetarian diet.
- In 2019, I purchased green electricity.
- In 2019, I switched off my electrical appliances completely (i.e., not only put them on standby).
- In 2019, I washed my laundry mainly at 60°C or higher. (R)
- In 2019, I paid more attention to the long term than to the price when making new purchases (e.g., electrical appliances, clothing).
- In 2019, I bought regional products rather than products transported over long distances.
- In 2019, I bought mainly waste-avoiding products (e.g., using no plastic bags for fruit and vegetables).
- In 2019, I heated my apartment to more than 22°C in the winter months. (R)

Note. To achieve a higher internal consistency, we excluded items with an (X), as described in the Methods section.

Appendix B

Questionnaire on pro-environmental intention. Participants answered on a 6-point-scale from "does not apply at all" to "fully applies". (R) indicates inversed items.

To what extent do these statements apply to you?

- In 2021, I would like to (continue to) mainly use a car for short distances (up to 20 km). (R)
- In 2021, I would like to,continue to) take trips by plane. (R)
- In 2021, I would like to (continue to) eat a vegetarian diet.
- In 2021, I would like to (continue to) purchase green electricity.
- In 2021, I would like to (continue to) switch off my electrical appliances completely (i.e., not only put them on standby).
- In 2021, I would like to (continue to) wash my laundry mainly at 60°C or higher. (R)
- In 2021, I would like to (continue to) pay more attention to the long term than to the price when making new purchases (e.g., electrical appliances, clothing).
- In 2021, I would like to (continue to) buy regional products rather than products transported over long distances.
- In 2021, I would like to (continue to) buy mainly waste-avoiding products (e.g., using no plastic bags for fruit and vegetables).
- In 2021, I would like to (continue to) heat my apartment to more than 22°C in the winter months. (R)

Appendix C

Questionnaire on moral emotions (guilt, shame, authentic pride, hubristic pride, thankfulness) in pro-environmental behavior. Participants answered on a 6-point-scale for each scenario, ranging from "do not agree at all" to "strongly agree".

Now we would like to ask you about the degree to which you agree with some statements regarding various imaginary scenarios. Please try to identify with these scenarios and imagine how you would act in this type of situation.

1) For ecological reasons, you have decided to travel less by car and more by bicycle. Accordingly, you have planned to ride your bike the short distance to visit someone in the evening. However, when the time comes, you feel exhausted and take the car again.

To what extent do you agree with the following statements?

- You would feel uncomfortable
- You would regret taking the car

2) Because the carbon footprint of meat consumption is so high, you want to eat less meat, but this is generally difficult for you. However, because you came across some new vegetarian grilling recipes you found it easy not to eat meat at the last barbecue.

To what extent do you agree with the following statements?

- You would think: "I can do more than I thought I could."
- You would think: "I did a good job."

3) Due to the poor carbon dioxide balance, you would like to fly less. However, you would like to visit a somewhat distant destination, and because it takes twice as long to get there by train as by plane, you book a last-minute flight.

To what extent do you agree with the following statements?

– You would feel uncomfortable about being inconsistent.
– You would regret not acting according to your principles.

4) For the sake of the environment, you have resolved to save electricity. However, you have a lot of devices you don't want to unplug every evening, so you buy a multi-socket device with a toggle switch. This means the devices don't just go into standby mode, but are actually switched off.

To what extent do you agree with the following statements?

– You would be happy to have found a solution yourself.
– You would think that you have handled the situation well.

5) To what extent do you agree with the following general statements (without reference to the scenarios)?

– I am grateful to live in a region of the world in which climate change will arrive later and be less extreme than in other regions.
– I am grateful to live at a time less affected by climate change than future generations apparently will be.

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Contextual and Individual Variables as Predictors of Energy-Dense Meals in Food Choices

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Diets based on meals that provide a large amount of energy and consumed frequently often increase the rate of growth of the body mass index (overweight or obesity) and, in turn, the risk of suffering from non-communicable diseases. In order to make a food choice, it is necessary to search for foods in the environment, taking into account physical and social variables (contextual variables) which, together with individual variables, delimit the situation of food selection. The objective of this study was to evaluate the effect of social facilitation, portion size, salience of food, and food preference or rejection on the selection of energy-dense foods by young college students. To do so, we performed a factorial experiment in which unaccompanied and accompanied participants (levels of social facilitation) as they went through the process of choosing from different options of main dishes, beverages, and desserts then noted the reasons for their selection (preference or rejection of the food). Results showed significant differences between the group of accompanied participants and salience of food in the selection of the energy-dense main dishes and desserts (pizza, spaghetti, and chocolate cake). A significant relationship was also identified between accompanied participants, hedonistic/sensory reasons (food preference or rejection category), and salience of food in the selection of the energy-dense main dishes. In conclusion, key findings of the variables that constitute the situation that predicts the selection of energy-dense foods have emerged from this study, when participants and the given level of social facilitation (in this case, being accompanied) were faced with the conditions of the food salience of the meals of their preference regarding its taste and appearance.

Keywords: eating situation, contextual variables, food choice, individual variables, energy-dense meals

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INTRODUCTION

Diet refers to the voluntary and personal behavior to obtain, prepare, and ingest food. To obtain them, people must adapt to the environment and go through the process of food choice, which is understood as taking daily decisions about the food that involve discriminating and choosing meals that will be consumed in accordance with the time of day. Moreover, there are also choices regarding where to eat, with whom to eat, or where to buy meals. This process enables individuals to fraction their daily portions of food both daily and during the day, based on their habits and circumstances by determining the consumption and frequency of meals. Therefore, the environment is the means for the organism to acquire necessary nutrients (Cervera et al., 2004; Poelman and Steenhuis, 2019;

Martín and Cantarero, 2020). More specifically, a diet that provides a large number of kilocalories that are not used as energy increases the accumulation of fat in the body, classified as overweight and obesity, which increases the risk of suffering non-communicable diseases and accounts for 71% of deaths worldwide in people between 30 and 69 years of age).

This topic has been studied using the concept of reference event, i.e., any event of interest related to food, e.g., menu planning or analysis of the bite of a food. The reference event is analyzed per unit of reference, and it could be a meal, a dish, or an eating pattern. In this study, the reference event is food selection and reference units are understood as meal formats, i.e., the size of a meal involving the combination of solid and liquid elements (Rozin and Tourila, 1993; Bell and Meiselman, 1995; Meiselman, 1996, 2006; Mäkelä, 2000; Mäkelä and Nivi, 2019).

The food choice process involves individual variables, e.g., expectations, habits, experiences, sensory, physiological, behavioral responses, and food characteristics such as odor, appearance, and taste. In accordance with these variables, people also interact with the variables of the context, i.e., the events and physical and social factors of the environment that influence the perception of the event of reference and, thus, the situation under which the food choice is made is formed (Rozin and Tourila, 1993; Bell and Meiselman, 1995; Meiselman, 1996, 2006).

In this study, individual variables have been analyzed using the concept of food preference or rejection proposed by Rozin (2007) whose categories of this concept were further developed based on the study by Rozin and Fallon (1980) and are defined as follows:

(1) *Hedonistic or sensorial reasons:* Preference or rejection determined by the taste, texture, smell, or appearance of food. The indicators in this category are understood as properties that a person evaluates subjectively (intrinsic factors) and the evaluation, in turn, is based on cultural or religious factors from a region, and on environmental factors (extrinsic factors), e.g., situational, marketing, and time variables (Khan, 1981; Shepherd and Sparks, 1994).

(2) *Anticipated consequences:* They could be related to beliefs about whether a food is dangerous, or beneficial to health, and also whether that food carries relatively rapid positive or negative post-ingestive consequences that can influence health. For example, a person might reject a food because he or she is allergic to it, or because he or she considers it to be high in energy (Rozin, 2007).

Contextual variables are understood as characteristics that are physically present during the food choice process, but that are not the food itself, e.g., labeling, packaging, the place where the food is presented (i.e., at a restaurant or at home), and additional to the presence of other people (Rozin and Tourila, 1993; Bell and Meiselman, 1995; Wansink and Sobal, 2007). In particular, Wansink and Sobal (2007) and Wansink (2004) understand these variables as environmental influences and organize them into two dimensions:

(1) *Food environment*: It refers to the presentation of food, e.g., portion size, as to say, a consumption norm that involves elements with which people normally interact on a daily basis and are indicators of how much to eat and when to finish eating (Wansink and Sobal, 2007) and Salience of Food or preponderance which refers to the storage of food products prominently or preponderantly at the point of consumption because they may take up more storage space, they can sometimes be packaged in unusual ways (promotional packages) and can be placed in visible locations, e.g., on the counter in front of the pantry (Chandon and Wansink, 2002).

(2) *Eating environment*: This involves social interactions in the dietary situation, including the concept of social facilitation, i.e., the presence of more people during a segment of the diet, whose company affects the amount of food to be consumed (Stroebele and De Castro, 2004).

In accordance with the above, there is evidence of the influence of some contextual variables, specifically the ones related to environmental properties. For example, in a study designed on a digital environment, salience was manipulated by varying brightness levels of meals regarded as healthy and non-healthy. The influence of salience of healthy products on food choice was also tested, even if the non-healthy product was regarded as better-tasting. Considering this, there is a belief that this factor is relevant when choosing food; even so, it is necessary for its measurement to be performed with a basis on complex decision-making, such as a meal's real eating environment (Dai et al., 2020).

Food portion size is considered to predict beverage choice; however, in a study performed by Ferrar et al. (2019), it was proven that given a variety of portion sizes in main dishes, beverage choice was taken according to the subjects' familiarity with the product (water or soft drink); yet the probability of choosing the better-known beverage increased if a larger portion was chosen.

An eating situation involves social interactions, which means that being in the presence of other people while having a meal has an impact on the amount of food consumed. This is known as social facilitation (Stroebele and De Castro, 2004). If the number of people influences the amount consumed, then it possibly also influences food choice (Bell and Meiselman, 1995) since it is believed that meal consumption is a matter of choice (Kjaernes and Holm, 2007).

Classically, food choice has been studied using images for its measurement and focused on the analysis of the selection of main dishes, snacks, or beverages, separately. However, the eating event involves more than one food and one beverage (Oltersdorf et al., 1999; Meiselman, 2008). Therefore, in this study, the measurement of variables was designed with real foods, which formed the plate or structured plates containing more than one food that are consumed at any time of the day (Meiselman, 1996, 2000). The objective of the study was to evaluate the effect of social facilitation, portion size, salience of food (contextual variables), and food preference or rejection (individual variables) on the selection of energy-dense meals (Meiselman, 1996, 2000).

METHODOLOGY

Participants

A total of 22 students aged 20–24 years (M = 21.8, σ = 0.958) from the sixth and eighth semesters of the medicine and clinical

biochemist majors in the University of Sonora, Cajeme campus, Mexico, were participated. Due to the demand of this study and the time and space availability in the university, participant selection was performed *via* the non-probabilistic technique of convenience type. This means that a sample was selected from an easy-to-access population, which prevents knowing the probability of participants being chosen (Ochoa, 2015).

Preparing and Presenting the Meals

The meal was composed of a main dish, dessert, and beverage. Everything was prepared in a homemade fashion, with known and frequently consumed foods by the participants. **Tables 1**, **2** show the ingredients and amounts present in the portions and their kilocalorie content. Participants who belonged to groups entered a room where there were several tables together, two types of dishes, desserts, and beverages available to each one of them.

Devices and Material

The sessions took place in a Gesell chamber at the laboratory of the University of Sonora which is equipped with computer devices that control three cameras installed in the room where the behavioral analysis occurs. There were four tables where all the food products were presented in biodegradable, disposable materials along with napkins and silverware. The meals were served at room temperature; however, participants had at their disposal a microwave within the facilities to heat their meals if they wished to do so. Beverages were presented at a cold temperature; therefore, they were kept inside an icebox filled with ice to maintain a good temperature. There were also white sheets of paper, pens, pencils, and other stationery items to record both the assistance and the motives for which the products were chosen by the participants in each session.

Procedure

The experiment was conducted on February 2020. Through the informed consent letter, all participants were made aware of the objective of the study and the activities to be performed and were asked for authorization to be filmed. The participants were separated into two groups and four sessions were assigned to each group. According to the group they belonged to, each participant entered the Gesell chamber of the University of Sonora where there were several tables, and two types of main dishes, two types of beverages, and two types of desserts available to be chosen for consumption were presented on the tables. Fifteen minutes were allotted for the activity, and when they concluded the task, they wrote down the reasons for selecting their food in a sheet of paper.

Data Analysis

To identify differences between groups or levels of social facilitation and portion size and food preponderance conditions, main effects were observed and pairwise comparisons were performed using analysis of variance (ANOVA) with repeated measures (RMs) and *post-hoc* tests with Bonferroni adjustment. To identify the degree of relationship between variables, three-dimensional contingency tables were constructed with the chi-square significance test (X^2) as a measure of association.

RESULTS

Interaction Effects Between Social Facilitation Levels and Portion Size

Regarding the interactions between social facilitation levels and portion size levels, no significant differences were found ($F = 1.016$, $df = 5.0, 15.0$, $p > 0.05$, $\eta^2 = 0.26$).

Interaction Effects Between Levels of Social Facilitation and Salience of Food

The interactions between the levels of social facilitation and the levels of food preponderance indicated that there are significant differences between the levels of social facilitation and the levels of food salience ($F = 4.31$, $df = 5.0, 14.0$, $p < 0.05$, $\eta^2 = 0.60$). According to the Bonferroni *post-hoc* test, such significant differences are found in the selection of dessert in session 3 depending on whether the participants were unaccompanied ($M = 1.10$, $\sigma = 0.316$, $p < 0.05$) or accompanied ($M = 1.60$, $\sigma = 0.516$). Significant differences were also found in the selection of the main dish in session 4 ($M = 1.50$, $\sigma = 0.527$, $p = 0.05$), while also when participants were accompanied in this session ($M = 1.10$, $\sigma = 0.316$).

Degree of Association Between Portion Size, Social Facilitation, and Food Preference or Rejection

According to **Tables 1**, **2**, the values indicate that there are no significant associations between levels of social facilitation, energy-dense main course, beverage and dessert selections according to portion size, and food preference or rejection categories. Therefore, neither hedonistic/sensory reasons nor anticipated consequences or portion size are related to the selections participants made.

Degree of Association Between Salience of Food, Social Facilitation, and Food Preference or Rejection

The values in **Table 3** indicate that there are no associations in levels of social facilitation, the preponderance of foods in their conditions, and food preference or food rejection categories. Therefore, it is assumed that the choices participants made were not related to hedonistic/sensory reasons or anticipated consequences.

Table 4 shows that there was only a statistically significant association between accompanied participants, main course selection (pizza and spaghetti) in preponderance condition, and hedonistic/sensory reasons.

DISCUSSION

This study confirmed the influence of contextual variables in the selection of energy-dense foods. Specifically, for accompanied participants, facing condition of the salience of foods with higher energy density, it was mainly the participant's context which

TABLE 1 | Chi-square results of main course, beverage, and dessert selection in session 1.

Conditions for choosing according to portion size	Social facilitation levels	Values of X^2
Main dish	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 1.575$ ($df = 2$), $p > 0.05$. $X^2 = 0.917$ ($df = 1$), $p > 0.05$.
Beverage	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 1.479$, ($df = 3$), $p > 0.05$. $X^2 = 3.600$ ($df = 4$), $p > 0.05$.
Dessert	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 0.321$ ($df = 1$), $p > 0.05$. $X^2 = 0.020$, ($df = 1$), $p > 0.05$.

TABLE 2 | Chi-square results of main course, beverage, and dessert selection in session 2.

Conditions for choosing according to portion size	Social facilitation levels	Values of X^2 per Group
Main Dish	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 1.397$ ($df = 2$), $p > 0.05$. $X^2 = 3.208$ ($df = 4$), $p > 0.005$.
Beverage	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 3.606$ ($df = 3$), $p > 0.05$. $X^2 = 5.238$, (df 2), $p > 0.05$.
Dessert	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 3.654$ ($df = 3$), $p > 0.05$. $X^2 = 7.222$ ($df = 2$), $p < 0.05$. (Contingency coefficient = 0.64, $p < 0.05$.)

TABLE 3 | Chi-square results of main course, beverage, and dessert selection in session 3.

Conditions for choosing according to portion size	Social facilitation levels	Values of X^2
Main Dish	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 0.278$, ($df = 1$), $p > 0.05$. $X^2 = 1.270$, ($df = 1$), $p > 0.05$.
Beverage	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 0.900$ ($df = 2$), $p > 0.05$. $X^2 = 4.518$ ($df = 2$), $p > 0.05$.
Dessert	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 0.278$ ($df = 2$), $p > 0.05$. $X^2 = 2.037$ ($df = 2$), $p > 0.05$.

TABLE 4 | Chi-square results of main course, beverage, and dessert selection in session 4.

Conditions for choosing according to portion size	Social facilitation levels	Values of X^2 per group
Main Dish	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 2.500$ ($df = 1$), $p > 0.005$. $X^2 = 9.000$ ($df = 2$), $p < 0.05$. (Contingency coefficient = 0.70, $p < 0.05$).
Beverage	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	$X^2 = 2.744$ ($df = 1$), $p > 0.05$. $X^2 = 1.667$($df = 1$), $p > 0.05$.
Dessert	Group 1: Unaccompanied Participants Group 2: Accompanied Participants	No statistics were computed for this group because the observed and expected frequencies have the same values. $X^2 = 0.625$ ($df = 1$), $p > 0.05$.

determined the selection of the main course (pizza and spaghetti) and dessert (a piece of chocolate cake) with said properties. A significant relationship was also found between context and hedonistic or sensory reasons (individual component). These variables shaped the situation of energy-dense food selection. These results show that eating behavior is mainly related to the elements of the environment where individuals behave, i.e., food choices are situational or circumstantial (Doucerain and Fellows, 2012; Sobal et al., 2014).

The social factor is considered to be one of the main components affecting food choice (Birkenhead and Slater, 2015), even though there are few experimental studies that examine social facilitation in relation to food selection (Ruddock et al., 2019). Thus, this study demonstrates the relevance of the

environment on eating behavior, specifically on food choice. The results encourage considering other variables for future testing, e.g., cultural norms or group processes, considered social affordances, are risky contextual features for increased body fat and cardiovascular disease. Making the choice to buy or not to buy and to consume a food or not implies a social and physical posture of the environment which enables dietary patterns (Carrus et al., 2018).

DATA AVAILABILITY STATEMENT

The datasets analyzed for this study can be obtained by contacting the correspondent author, these will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Comité de Ética en Investigación de la Universidad de Sonora. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. The patients/participants provided their written informed consent to participate in this study. The individual(s) provided their written informed consent for the publication of any identifiable images or data presented in this article.

AUTHOR CONTRIBUTIONS

DB-M contributed to the conceptualization, design of this study, and acquisition of data, ran formal analysis, and organized databases. CT-F contributed by supervising this study, its methodological tasks, and data interpretation. BF-S made substantial contributions by editing and revising the manuscript critically for important intellectual content. DB-M and CT-F provided the writing of the original draft. All authors contributed to the manuscript revision and read and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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ORIGINAL RESEARCH
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Should I Stay or Should I Go? Risk Perception and Use of Local Public Transport During the COVID-19 Pandemic

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In light of the climate crisis, the transport sector needs to be urgently transformed and the number of users of local public transport needs to be increased. However, the first year of the COVID-19 pandemic severely affected public transport with passenger numbers declining up to 80% in Germany. In addition to a general decrease in mobility during lockdowns, we can observe a shift in decision-making in regards to modes of transportation, with public transport losing out. We argue that this change in behavior can be explained by the fact that people tend to overestimate the risk of COVID-19 transmission in public transport. In order to understand risk perception in users and non-users of public transport during the pandemic, a representative survey (N = 918) in a German major city was conducted at the peak of the third wave of the pandemic in April 2021. We identified four main target groups of public transport use during the pandemic: Loyal users (n = 193), reducers (n = 175), pandemic-dropouts (n = 331) and non-users (n = 219). We found reducers (r = 0.12), pandemic-dropouts (r = 0.32) and non-users (r = 0.22) to perceive an increased perception of infection risk for public transport as compared loyal users. This increased risk perception was specific to public transport – it did not generalize to other day-to-day situations, such as going to the grocery store or visiting a hairdresser. This finding can be taken as an indication that risk perception for an infection plays a crucial role in stepping back from public transport use during the pandemic. In addition, however, there were other differences in terms of needs and concerns between the different target groups during the pandemic. Based on our findings, we discuss which tools and interventions might convince these different groups to hop-(back)-on public transport. Our study highlights how risk perception will play an important role in attracting new and former passengers and is the basis for the interventions and developments that will build a pandemic-resistant public transport in the future.

Keywords: COVID-19, risk perception, public transport, mobility, pandemic resilience, protection motivation theory (PMT), climate change

INTRODUCTION

The German climate protection goals as named in the Federal Climate Change Act (Bundes-Klimaschutzgesetz, 2019; Hendzlik et al., 2021) require the German transport sector to decrease its greenhouse gas emissions by an equivalent of 85 million tonnes of CO_2 by 2030 (Hendzlik et al., 2021). While the transport sector accounted for 20% of German greenhouse gas emissions in 2019, the envisioned target implies that the transport sector's yearly emissions must be reduced by half within the next 8 years. This requires a fundamental transformation of the German traffic system. An expansion of local public transport (in the following: public transport) is one of the eight core-components of the German Federal Agencies' action plan to realize this transformation (Hendzlik et al., 2021); Especially in urban areas where a great number of potential passengers could be transported on a relatively small amount of space, the advantages of local public transport could be played out against motorized individual mobility. In this way, public transport could play an important role in replacing cars. After all, the political aim prior to the pandemic was to double passenger numbers in public transport by 2030 (German Federal Government, 2018). The current coalition contract of the German Federal Government (2021) has an even more ambitious aim: to double the traffic performance by 2030, hence to double supply instead of doubling demand. This aim depends even more on an increase of passenger numbers.

However, since early 2020, the COVID-19 pandemic has been thwarting these ambitious plans: While public transport was considered critical infrastructure during the pandemic and was therefore provided on a constant level of around 80–100% (VDV, 2020), declines in its use by up to 80% (VDV, 2020) were observed, leaving buses and trains empty and abandoned. The resulting declines in revenues from ticket sales set public transport operators under financial pressure and consequently made governmental rescue packages necessary (Fedra, 2021; Verkehrsministerkonferenz, 2021). Today, after 2 years of the pandemic, passenger numbers in public transport have still not returned to 2019 levels (DLR Transport, 2022b). Public transport has lost about ten percent of their regular customers and a new normal – one with reduced public transport usage – seems to have established itself (DLR Transport, 2022b).

There are two main reasons for the word wide decline of public transport use during the pandemic. Firstly, a general reduction in the number and distance of trips among all modes of transportation (DLR Transport, 2022a,b); this general reduction can be considered a direct consequence of the lockdown (Askitas et al., 2021). Due to official regulations, people started working from home or were short time working, students did not go to school anymore, and social events of all sorts were canceled. People reported having generally fewer reasons to travel (DLR Transport, 2022b). In addition to this general decrease in mobility, however, a shift in the choice of transportation mode was observed, with public transport losing out (DLR Transport, 2022a). In the study of Finbom et al. (2020), participants from Germany reported a mode shift from public transport (bus, tram, and metro) to car, bicycling, and walking. In the study of Shibayama et al. (2021), a large shift from public transport to home office was noticed, but some participants also reported shifting to car and bicycling. In the April/May 2021 panel of DLR Transport, 53% of participants reported using public transport less or much less, whereas walking (+26%), bicycling (+18%), and car (+14%) usage had increased.

Protection motivation theory (Rogers, 1975; Floyd et al., 2000) suggests that risk perception might have played a role in these trends concerning the use of public transport: Since the beginning of the pandemic, public transport was stigmatized as an infectious space in public health communication campaigns (Tirachini and Cats, 2020). The perception of public transport as a high-risk environment might have triggered protection motivation in form of a general avoidance of traveling (Zheng et al., 2021) and a specific avoidance of public transport (e.g., Finbom et al., 2020; Shibayama et al., 2021; DLR Transport, 2022b). A positive relationship between risk perception and protective behavior is already known from other pandemics and infectious disease outbreaks (for a review, see Bish and Michie, 2010). Regarding the COVID-19 pandemic, empirical evidence suggests that risk perception determines hygiene and social distancing behavior (Majid et al., 2020; Wise et al., 2020). Indeed, when asked about their COVID-19 related risk perceptions, people reported feeling much more inconvenient in public transport since the beginning of the pandemic, but not when bicycling and walking (DLR Transport, 2022a,b). While the car was perceived as a safe space, metro, tram, train and bus were perceived as high-risk environments (Finbom et al., 2020). In the survey of DLR Transport (2022b), former public transport users spoke of the hygiene in the vehicles and the inability to keep their distance from other passengers as the two main reasons for deciding against using buses and trams within the pandemic. Shibayama et al. (2021) found that 72% of those who shifted from public transport to other travel modes reported to do so because of an increased risk perception in public transport. A more differentiated look on users and non-users of public transport during the pandemic revealed an interesting pattern. Whereas ongoing public transport users perceived themselves at greater susceptibility of infections than non-users in the study of Costa (2020), Finbom et al. (2020) report a reverse relationship. In their study, those who avoided using public transport during the COVID-19 pandemic reported to perceive an increased infection risk during public transport use as compared to other day-to-day situations (e.g., going to a warehouse) and as compared to the ones who continued using public transport. These contradictory findings might in part be explained by the fact, that – of course – not all individuals have the opportunity, in terms of means and finances, to perform protective behaviors in response to risk perception, such as avoiding public transport (d'Arbois de Jubainville and Vanier, 2017). Finbom et al. (2020) showed that education level and the working situation, as well as income, affected transport mode choice during the pandemic. People with lower income reported lower access to alternatives to public transport. In the same vein, in the study of Shibayama et al. (2021) those who continued to use public transport reported to do so, because they had no other opportunity.

This increased risk perception for public transport stands in contrast to considerations (Sommer et al., 2021), that the objective infection risk is rather low in public transport: Two thirds of trips in public transport have a duration of less than 15 min, making contact to others very brief (Sommer et al., 2021). Efficient fresh air ventilation systems (Greenhalgh et al., 2022) and mask wearing protects very well against infections (Chu et al., 2020; Ueki et al., 2020; Bagheri et al., 2021) and has become the new norm in public transport. Moreover, initial empirical findings have also reported no increased risk of infection for users of public transport (Charite Research Organisation [CRO], 2021; Galmiche et al., 2021).

In our study, our goal was to investigate the impact of COVID-19 risk perception on public transport use in a representative sample of a German major city. As reported, there is already a lot of research regarding COVID-19 and public transport (e.g., Finbom et al., 2020; Shibayama et al., 2021; DLR Transport, 2022a,b). However, most of the existing evidence on risk perception stems from samples recruited *via* snowball sampling (Shibayama et al., 2021), involving open online questionnaires, in which self-selection processes could have distorted the results, or the surveys included (former) public transport subscribers only (e.g., Finbom et al., 2020; Charite Research Organisation [CRO], 2021). We aimed to extend these findings by focusing on a representative sample for a German major city, allowing us to draw general conclusions concerning risk perception and its effects on public transport use in urban areas and recommend strategies for bringing people back to public transport after the pandemic. First, we quantified changes in mobility patterns in the representative sample taken during the pandemic. We assessed the frequencies of transport mode usage and mode shifts during the pandemic to determine how many people continued using public transport during the pandemic, how many reduced or dropped out of public transport during the pandemic, and how many were general non-users. We next wanted to understand to what extent public transport fulfilled different needs and concerns of mobility during the pandemic. Therefore, we evaluated infection risk perceptions for public transport, but also determined which criteria were generally perceived as relevant for the choice of transport mode during the pandemic, to what extent they were fulfilled in public transport and which measures meant to prevent COVID-19 transmission in public transport were perceived as important. To understand to what extent these needs and concerns determined transport mode choice during the pandemic, we looked at differences between the four target groups regarding these needs and concerns. Thereby, we aimed to identify leverage points to bring people back to public transport after the pandemic.

MATERIALS AND METHODS

Data Collection

An online questionnaire implemented with Lime Survey (Lime Survey Community Edition, version 3.27.19) was applied. The questionnaire was provided in German, English, Turkish, and Russian. For people who had difficulties with this online format the option of telephone participation was offered.

Participants

A representative sample of 3000 people aged between 14 and 85 years was drawn from all residents of a German major city. The drawing was conducted by the city's residents' registration office. All selected individuals were invited to participate *via* an individualized letter sent to their private address, containing a one-euro piece as incentive for participation. The survey was conducted during the second lockdown in Germany (Kodzo and Imöhl, 2022), between April 21st 2021 and May 12th 2021. During this period, the local 7-day COVID-19 incidence ranged between 152 and 234 per 100,000 residents and the vaccination rate was still low, increasing from 21 to 36% during the survey period (Statista, 2022). At the end of the first week of the survey, the previously discussed and announced measure of mandatory wearing of an FFP2 mask in public transport was implemented by law (Federal Ministry of Health, 2021). During the survey period, the online questionnaire was accessed 1065 times. After excluding inadmissible values (participation code not assignable: $n = 9$; did not finish the survey or skipped more than 15% of questions: $n = 130$, no information in public transport mode change $n = 8$) the final data set consisted of $N = 918$ participants. This corresponds to a response rate of 31%. Participants ($n_{female} = 465$; $n_{male} = 453$; $n_{diverse} = 0$) were aged between 14 and 86 years ($M = 47.64$, $SD = 18.57$). A detailed overview over socio-demographics can be found in **Table 1**.

Measurements

The questionnaire was structured in three parts. In the first part, participants were asked about their current mobility patterns and reported which factors generally influence their mode choice of transport. In the second part, participants evaluated several occupation scenarios of vehicles. This part of the questionnaire will be analyzed in a separate paper and is therefore not further considered here. COVID-19 related questions on perception of infection risk and the evaluation of the different measures were addressed in the third part. The questionnaire ended with a section on socio-demographic data. On average, the participants needed 25 min to complete all questions.

Frequency and Modes of Transportation Used During the Pandemic

The frequency of using different means of transportation during the pandemic was evaluated on an item that was taken from Nobis and Kuhnimhof (2018): "When thinking about the last month, how often did you use the following means of transportation?". Participants reported the frequency of having used the transportation modes walking, bicycling, pedelec, bus, tram, train, car – driving, car – passenger, motor bike on an ordinal scale with the response options "I do not have access to this mode," "seldom or never," "1 to 3 days per month," "1 to 3 days per week," and "(almost) daily."

TABLE 1 | Sociodemographic characteristics of participants.

			Target Groups							
	Total *N* = 918		**Loyal *n* = 193**		**Reducers *n* = 175**		**Dropouts *n* = 331**		**Non-users *n* = 219**	
	n	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Gender										
Female	465	51	96	50	98	56	170	51	101	46
Divers	0	0	0	0	0	0	0	0	0	0
Male	453	49	97	50	77	44	161	49	118	54
Occupation*										
Employed	495	54	80	41_{D}	84	48_{D}	200	$60_{L,R}$	131	60
Not employed	38	4	4	2	8	5	13	4	13	6
Retired	210	23	50	26	37	21	70	21	53	24
Student	142	15	55	39_{D}	38	27_{D}	34	$24_{L,R}$	15	11
Care work	23	3	3	2	7	4	11	3	2	1
Language										
German	913	99	192	99	175	100	329	99	217	99
English	1	0	0	0	0	0	0	0	1	0
Russian	4	0	1	1	0	0	2	1	1	0
Financial situation										
Very stable	384	42	73	38	63	36	148	45	100	46
Stable	315	34	68	35	69	39	114	34	64	29
Rather stable	152	17	37	19	29	17	51	15	35	16
Rather precarious	43	5	7	4	13	7	14	4	9	4
Precarious	8	1	4	2	1	1	1	0	2	1
Vaccinated against COVID-19										
Yes	247	27	53	27	40	23	86	26	68	31
No	622	68	131	68	129	74	226	68	136	62
No response	49	5	7	4	4	2	14	4	11	5
Risk Group										
Yes	319	35	70	36	59	34	114	34	76	35
No	424	46	90	47	88	50	142	43	104	47
No response	175	19	31	16	26	15	73	22	37	17
Already infected with COVID-19										
Yes	35	4	11	6	7	4	10	3	7	3
No	844	92	176	91	163	93	306	92	199	91
No response	39	4	3	2	3	2	11	3	10	5
Dependance on PT*										
Reliant on PT	134	15	83	$43_{R,D,N}$	44	$25_{L,D,N}$	6	$2_{L,R}$	1	$0_{L,R}$
Alternatives but PT preference	140	15	69	$36_{R,D,N}$	40	$23_{L,D,N}$	22	$7_{L,R}$	9	$4_{L,R}$
Alternatives and preferred	408	44	27	$14_{R,D,N}$	69	$39_{L,D,N}$	207	$63_{L,R}$	105	$48_{L,R}$
PT not accessible	231	25	14	$7_{R,D,N}$	21	$12_{L,D,N}$	95	$29_{L,R}$	101	$46_{L,R}$
Ticket										
Single or short trip ticket	86	9	36	19	50	29	NA	NA	NA	NA
Group ticket	32	3	19	10	13	7	NA	NA	NA	NA
Weekly/monthly pass, no subsc.	19	2	11	6	8	5	NA	NA	NA	NA
Annual/monthly pass. with subscr.	33	4	18	9	15	9	NA	NA	NA	NA
Semester/School/Seniors Ticket	110	12	59	31	51	29	NA	NA	NA	NA
Job ticket, BC100, handicapped ID	72	8	42	22	29	17	NA	NA	NA	NA
Never use public transport	1	0	1	1	0	0	NA	NA	NA	NA
Other	36	4	7	4	9	5	NA	NA	NA	NA

*PT, public transport. subsc., subcription. *$p < 0.006$ (Bonferroni-corrected for the nine omnibus tests) in the omnibus Chi-squared test. Pairwise group comparisons (Bonferroni-corrected $p_{crit} = 0.008$) are based on pairwise two-sided Pearson's Chi-squared test with Yates' continuity correction. For each significant difference between the target group in the column header and the other target group(s), the letter of the significantly different group (L, loyal users; R, reducers; D, dropouts; N, non-users) appears as subscript.*

Transport Mode Shift During the Pandemic

Mode shift during the pandemic was assessed with the item "Did the COVID-19 pandemic influence your transport mode choice? Due to the COVID-19 pandemic I use…". Participants evaluated their change in using the transport modes walking, bicycling, pedelec, bus and tram, car – driving, car – passenger, motor bike, from before the pandemic to during the pandemic on an ordinal scale with the response options "much decreased," "decreased," "no change," "increased," and "much increased."

Infection Risk Perception

Participants were asked to evaluate their perceived infection risk for ten different day-to-day situations. In addition to public transport (using bus and tram), the day-to-day situations going to the grocery store, going to work, going to school, meeting friends at home, going out for a walk, going to the hairdresser, and taking a cab were selected. Participants were asked to evaluate the perceived infection risk of these specific situations on a five-point Likert-scale ranging from 1 (very low) to 5 (very high).

Criteria of Transport Mode Selection

To understand participants' general criteria when it comes to transport mode selection, we applied the multiple-selection item "We would like to know the reasons for which you choose of the above-mentioned means of transport: Which factors are important to you when choosing your means of transport?" The following response options were presented in a randomized order: accessibility, comfort, costs, ease of planning, ease of use, flexibility, fun, privacy, protection against accidents, protection against infections, protection against harassment, discrimination and violence, reachability, reliability, sustainability, travel duration, weather, other.

Satisfaction With These Criteria in Public Transport

In a next step, participants were asked to evaluate to what extent these criteria were fulfilled in public transport. Therefore, the fulfilment of each of the criteria named above was evaluated on a five-point Likert-scale ranging from 1 (very bad) to 5 (very well) fulfilled in public transport.

Evaluation of Measures Taken in Public Transport to Decrease the Infection Risk

Finally, we presented 16 measures taken to reduce the objective infection risk in public transport during the pandemic. The measures were the result of our systematic research on measures in public transport that had already been implemented or were discussed up to the time of the survey. They comprised policy measures within the vehicle, such as mandatory mask wearing, and entrance only with a negative test, digital measures such as an advance occupation information tool and contactless ticket purchase, measures to maintain distance within the vehicle, such as blocked seats and protective screens, but also service and infrastructural measures such as providing disinfectants and masks. We asked: "Which of these measures would have to be implemented in order to enable you to use public transport under pandemic conditions with a good and safe feeling?" Each of the presented measures was evaluated by the participants on a five-point Likert-scale ranging from 1 (very unimportant) to 5 (very important).

Socio-Demographic Data

Participant's gender, age, their financial and occupational status were assessed as demographic data. These questions were based on the questionnaire from Finbom et al. (2020). We furthermore assessed if participants or their household members belonged to a risk group, asked about their current vaccination status and whether they had already been infected with COVID-19. We also evaluated to what extent participants could choose between different modes of transportation and which ticket they usually selected.

Data Elaboration

Data sets including non-assignable code (n = 9), more than 15% of skipped questions (n = 130), or no information concerning the variable transport mode use or transport mode shift (n = 8) were coded invalid data and excluded from the dataset, resulting in a final sample of N = 918. Based on the two items for transport mode use during the pandemic and transport mode shift from before the pandemic, we computed the variable target group. In a first step, participants who reported currently using public transport (i.e., bus or tram) "(almost) daily," "1 to 3 days per week," or "1 to 3 days per month," were coded as "ongoing public transport users." Participants who reported using public transport "seldom or never," and those having "no access" to this mode were coded as current "non-users." In a subsequent step, those "ongoing public transport users" who reported having "strongly increased," or "increased" the use of bus and tram or reported "no change," were coded as "loyal users" (n = 193). Ongoing public transport users who reported having "decreased," or "strongly decreased" the use of bus and trams during the pandemic were coded as "reducers" (n = 175). In turn, current "non-users" who reported having "decreased," or "strongly decreased" the use of bus and trams during the pandemic were coded as "pandemic "dropouts" (n = 331), and those who reported "no change" were coded as "non-users" (n = 219) (see also **Figure 1**).

Data Diagnostics

In the case of missing values, the list-wise case exclusion was applied. Therefore, only cases were considered in which all variables involved had valid expressions. Therefore, the number of cases evaluated varies depending on the variable.

Statistical Procedure

Statistical analyses were performed with R Studio (Version 1.4.1717). When more than two groups were compared, the significance level (p_{crit} = 0.05) was adjusted using Bonferroni correction.

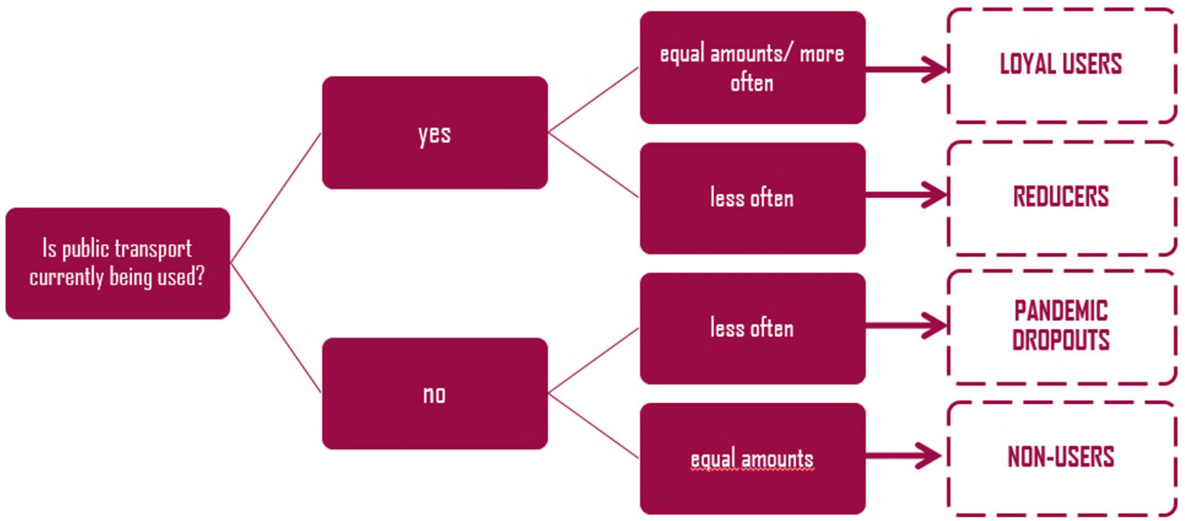

FIGURE 1 | Target groups of public transport use during the pandemic.

RESULTS

Transport Mode Use Before and During the Pandemic and Target Groups

Frequency and mode of transportation used during the pandemic are illustrated in **Figure 2**. Looking at public transport, 38% of the participants reported having used the tram and 25% the bus at least 1 to 3 days per month within the last month. Only 10% used the tram and 6% used the bus daily.

Transportation mode shift from before the pandemic to during the pandemic is illustrated in **Figure 3**. Most participants reported having strongly decreased or decreased their public transport use (i.e., bus and tram). In contrast to this, other modes of transport were increasingly used during the pandemic: 54% reported having increased or strongly increased walking, 39% report having increased or strongly increased car usage, and 25% reported having increased or strongly increased bicycling.

Socio-demographic characteristics for the four target groups can be found in **Table 1**. An explorative one-way ANOVA revealed significant differences concerning the age of participants in the four target groups, $F(3, 914) = 5.35$, $p = 0.001$. Follow-up pairwise comparisons ($p_{crit} = 0.008$) revealed that loyal users ($M = 43.99$ years, $SD = 21.46$) were significantly younger as compared to non-users ($M = 50.35$ years, $SD = 17.31$), $p = 0.003$, $d = 0.59$, 95% CI [0.13; 0.52]. Chi squared tests ($p_{crit} = 0.008$) also revealed large significant differences between the target groups concerning the distribution of occupational statuses, $d = 0.60$, 95% CI [0.47; 0.74], and participants' dependency on public transport, $d = 1.85$, 95% CI [1.67; 2.02]. The results of follow-up pairwise comparisons can be found in **Table 1**. To sum them up, we found that ongoing users of public transport were less often employed and more often students than dropouts and non-users. They were more often dependent on public transport but also more often preferred public transport even though alternatives were present than dropouts and non-users. In turn, dropouts and non-users more often reported preferring alternatives over public transport or having no access to public transport.

Infection Risk Perception in Public Transport

The perceived infection risk for public transport in comparison with other day-to-day situations in the total sample is illustrated in **Figure 4**. A Wilcoxon signed rank test on paired samples revealed no difference concerning risk perception of using tram or bus ($p = 0.307$). We therefore did not differentiate between these two forms of public transport in the following tests and compared the other day-to-day situations with using the tram only. Multiple Wilcoxon signed rank test on paired samples ($p_{crit} = 0.006$) revealed that out of all situations considered, only the risk of attending school was evaluated significantly higher than the use of public transport (i.e., the tram), $V = 56025$, $p = 0.004$. All other situations, that is being in the workplace, $V = 132533$, $p < 0.001$, meeting friends at home, $V = 171906$, $p < 0.001$, taking a cab, $V = 175925$, $p < 0.001$, going to the grocery store, $V = 158121$, $p < 0.001$, going to the hairdresser, $V = 225711$, $p < 0.001$, and going for a walk, $V = 396303$, $p < 0.001$, were perceived as significantly less risky as compared to using the tram. We hence found public transport (i.e., bus and tram) to be ranked second highest after attending school.

We now looked for differences concerning risk perception between the four target groups (see **Table 2**). Nine Kruskal Wallis tests ($p_{crit} = 0.006$) revealed differences between the target groups regarding perceptions of infection risk for using the tram, the bus, and the cab, but not for going to school, to work, meeting friends at home, going to a grocery store, going to the hairdresser, and going for a walk. Pairwise follow-up tests ($p_{crit} = 0.008$) revealed that loyal users perceived lower

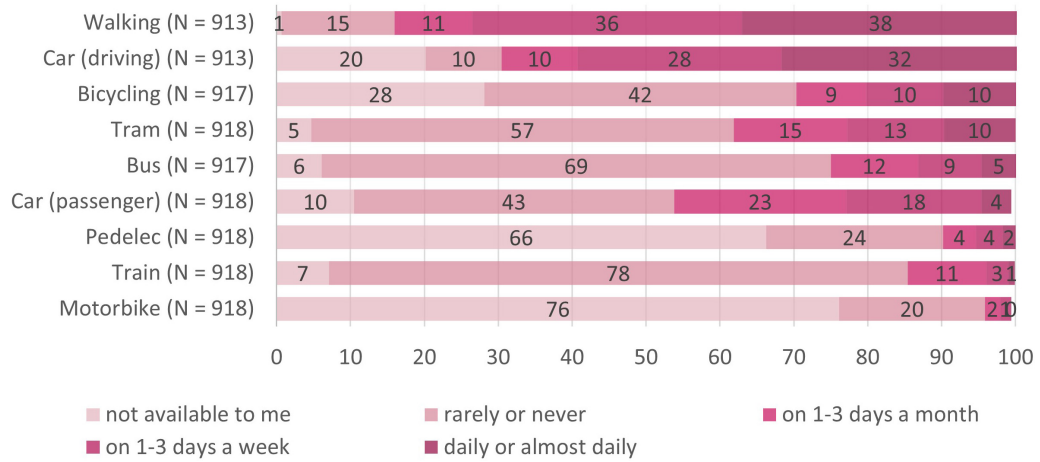

FIGURE 2 | Means of transportation used in the last month. *N* = 918; numbers on the bars represent percentages.

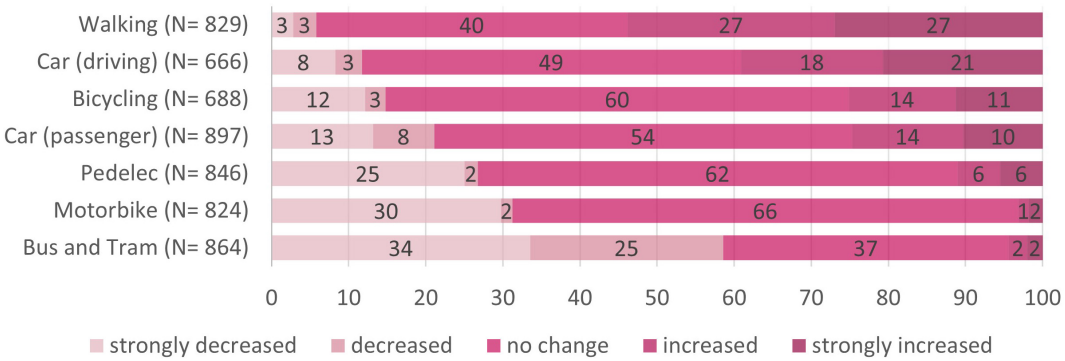

FIGURE 3 | Transport mode shift from before to during the COVID-19 pandemic. *N* = 918; numbers on the bars represent percentages.

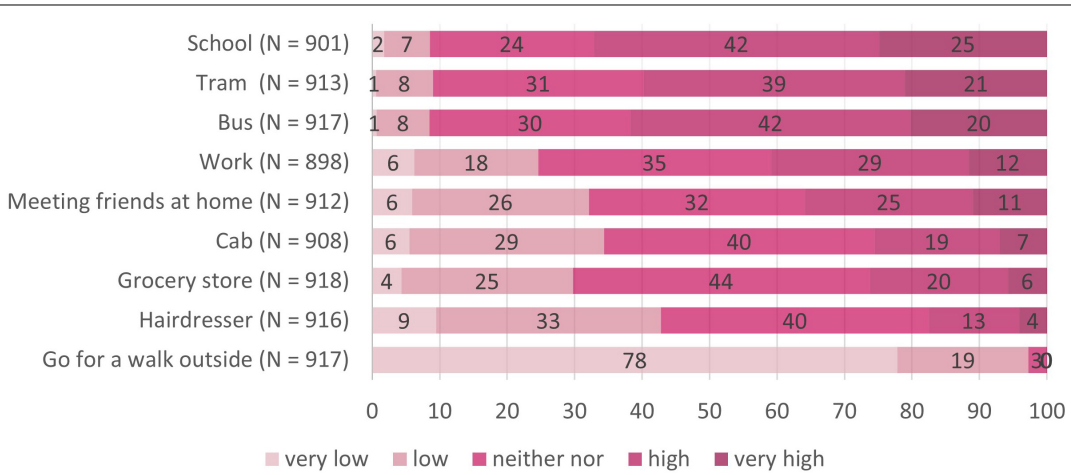

FIGURE 4 | Subjective risk perception in different day-to-day situations. *N* = 918; numbers on the bars represent percentages.

TABLE 2 | Infection risk as evaluated by the four target groups.

	Loyal (L) n = 193			Reducers (R) n = 175			Dropouts (D) n = 331			Non-users (N) n = 219			Total Sample N = 918				
	n	*Mdn*	*IQR*	n	*Mdn*	*IQR*	n	*Mdn*	*IQR*	n	*Mdn*	*IQR*	N	*Mdn*	*IQR*	$H(3)$	p
Bus*	193	$3_{R,D,N}$	1	175	$4_{L,D}$	1	331	$4_{L,R}$	1.5	218	4_{L}	1	917	4	1	61.92	<0.001
Tram*	192	$3_{D,N}$	1	174	4_{D}	1	328	$4_{L,R}$	2	219	4_{L}	1	913	4	1	58.08	<0.001
School	188	4	1	174	4	2	325	4	2	214	4	1	901	4	1	7.48	0.058
Meeting friends at home	193	3	2	171	3	2	330	3	2	218	3	2	912	3	2	1.53	0.676
Cab*	189	3_{D}	1	171	3_{D}	1	330	$3_{L,R}$	2	218	3	1.75	908	3	2	17.96	<0.001
Grocery	193	3	2	175	3	1	331	3	2	219	3	2	918	3	2	2.35	0.504
Hairdresser	193	3	1	175	3	1	329	3	1	219	3	1	916	3	1	5.49	0.139
Work	185	3	1	174	3	1	323	3	1	216	3	2	898	3	1	7.28	0.063
Walk	192	1	1	175	1	0	331	1	0	219	1	0	917	1	0	6.85	0.077

*Mdn, Median; IQR, interquartile range. *$p < 0.003$ (Bonferroni corrected for the 17 omnibus tests) in the Chi-squared omnibus test. Pairwise group comparisons are based on two-sided Pearson's Chi-squared test with Yates' continuity correction (Bonferroni corrected $p_{crit} = 0.008$). For each significant difference between the target groups, the letter of the significantly different group (L, loyal users; R, reducers; D, dropouts; N, non-users) appears as subscript in the column header and the other target group(s). Mdn: 5 = very high, 4 = high, 3 = neither nor, 2 = low, 1 = very low.*

infection risk than reducers in buses, $W = 20450$, $p < 0.001$, $r = 0.19$, and trams, $W = 18840$, $p < 0.001$, $r = 0.12$, than dropouts in buses, $W = 44123$, $p < 0.001$, $r = 0.34$, trams, $W = 42781$, $p < 0.001$, $r = 0.32$, and cabs, $W = 37354$, $p < 0.001$, $r = 0.17$, and as non-users in buses, $W = 27008$, $p < 0.001$, $r = 0.26$, and trams, $W = 26124$, $p < 0.001$, $r = 0.22$ (see also the subscripts in **Table 2**). Hence, reducers, dropouts and non-users had an increased perception of infection risk for public transport compared to loyal users, that did however not generalize to other day-to-day situations (see also **Figures 5–7**) for the risk evaluations for using the tram, the bus and the cab.

Criteria of Transport Mode Selection

Figure 8 summarizes the criteria determining transport mode choice during the pandemic in our sample. Flexibility, ease of use, planning, travel duration, and comfort were the top five selected criteria influencing transport mode selection.

Rankings of the criteria of transport mode selection in each of the four target groups can be found in the Supplementary (**Supplementary Figures 1–4**). In order to inspect differences in the distribution of the criteria between the target groups, we conducted fifteen Chi-squared tests ($p_{crit} = 0.003$; see **Table 3**). No differences between the groups were found concerning the importance of flexibility, ease of use, ease of panning, and duration of travel. These were the top criteria of transport mode selection in all four groups. However, differences between the target groups were found concerning the factors comfort, reachability, protection against infections, sustainability, costs, privacy, and protection against accidents.

We followed up these significant results by means of pairwise follow up Chi-squared tests ($p_{crit} = 0.008$). The results of these tests can be found as subscripts in **Table 3**. In the following, we will highlight the preferences of each target group in comparison to the other groups.

Loyal users evaluated sustainability, reachability, costs, and protection against accidents more often as important factor concerning their transport mode selection compared to one or more other groups. Sustainability was evaluated more often as important in comparison to dropouts, $\chi^2(1, N = 524) = 34.97$, $p < 0.001$, $d = 0.40$, 95% CI [0.27; 0.53] and non-users, $\chi^2(1, N = 412) = 59.49$, $p < 0.001$, $d = 0.53$, 95% CI [0.39; 0.66]. Reachability was evaluated significantly more often as important as compared to non-users, $\chi^2(1, N = 412) = 12.78$, $p < 0.001$, $d = 0.24$, 95% CI [0.11; 0.37] and dropouts, $\chi^2(1, N = 524) = 8.51$, $p = 0.003$, $d = 0.19$, 95% CI [0.06; 0.32]. Costs were evaluated more often as important as compared to dropouts, $\chi^2(1, N = 524) = 18.92$, $p < 0.001$, $d = 0.29$, 95% CI [0.16; 0.42], and non-users, $\chi^2(1, N = 412) = 21.81$, $p < 0.001$, $d = 0.31$, 95% CI [0.18; 0.44]. Protection against accidents was evaluated more often as important as compared to dropouts, $\chi^2(1, N = 524) = 7.99$, $p = 0.005$, $d = 0.19$, 95% CI [0.06; 0.32] and non-users, $\chi^2(1, N = 412) = 10.74$, $p = 0.001$, $d = 0.22$, 95% CI [0.09; 0.35]. To conclude, loyal users were not as concerned about infection risk as other groups were, and one of the most important criteria for loyal users for keeping on using public transport was sustainability, but also reachability and costs.

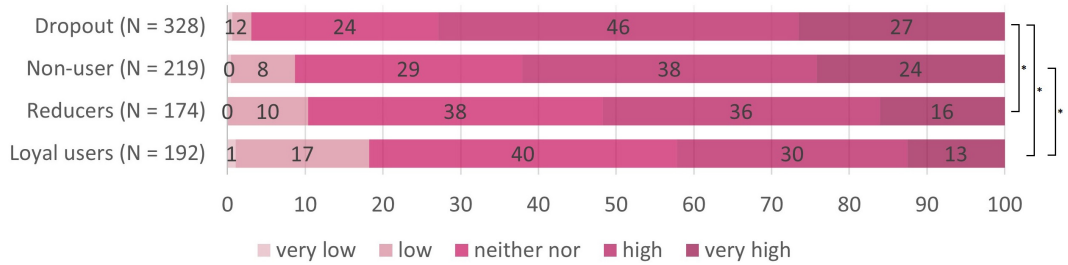

FIGURE 5 | Subjective risk perception for using the tram in the different target groups. $N = 918$; numbers on the bars represent percentages. *$p < 0.008$ in the pairwise comparisons.

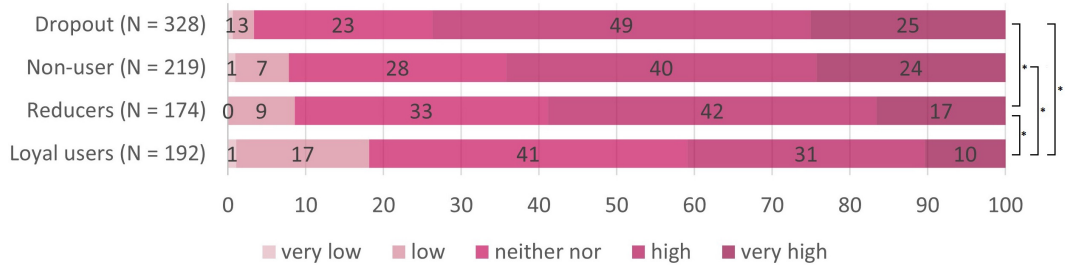

FIGURE 6 | Subjective risk perception for using the bus in the different target groups. $N = 918$; numbers on the bars represent percentages. *$p < 0.008$ in the pairwise comparisons.

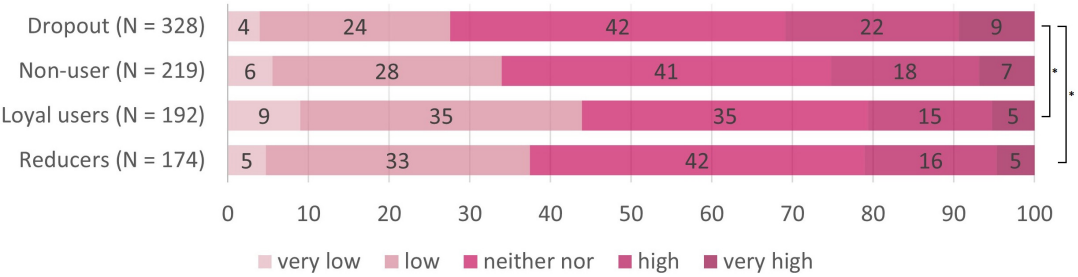

FIGURE 7 | Subjective risk perception for using the cab in the different target groups. $N = 918$; numbers on the bars represent percentages. *$p < 0.008$ in the pairwise comparisons.

Reducers evaluated reachability, sustainability, protection against infections and costs significantly more often as important criteria for transport mode selection as compared to other groups. Protection against infection was evaluated more often as important as compared to loyal users, $\chi^2(1, N = 368) = 17.64$, $p < 0.001$, $d = 0.28$, 95% CI [0.15; 0.41]. Reachability evaluated more often as important as compared to dropouts, $\chi^2(1, N = 506) = 10.51$, $p = 0.001$, $d = 0.22$, 95% CI [0.09; 0.35], and to non-users, $\chi^2(1, N = 394) = 10.10$, $p = 0.001$, $d = 0.21$, 95% CI [0.08; 0.34]. Sustainability was evaluated more often as important as compared to dropouts, $\chi^2(1, N = 506) = 23.91$, $p < 0.001$, $d = 0.33$, 95% CI [0.20; 0.46], and non-users, $\chi^2(1, N = 394) = 38.00$, $p < 0.001$, $d = 0.42$, 95% CI [0.28; 0.55]. Costs were evaluated more often as important as compared to dropouts, $\chi^2(1, N = 506) = 14.83$, $p < 0.001$, $d = 0.26$, 95% CI [0.13; 0.39] and non-users, $\chi^2(1, N = 394) = 14.59$, $p < 0.001$, $d = 0.25$, 95% CI [0.12; 0.38]. To conclude, in contrast to loyal users, reducers considered infection as a relevant criterion for transport mode selection. However, this group also considered sustainability, reachability and costs as important criteria for the continued use of public transport during the pandemic.

Dropouts evaluated protection against infections and privacy significantly more often as important criteria for transport mode selection as compared to other groups. Protection against infections was evaluated more often as important as compared to loyal users, $\chi^2(1, N = 524) = 63.03$, $p < 0.001$, $d = 0.54$, 95% CI [0.41; 0.68], reducers, $\chi^2(1, N = 506) = 9.78$, $p = 0.001$, $d = 0.21$, 95% CI [0.08; 0.34], and non-users, $\chi^2(1, N = 550) = 24.13$, $p < 0.001$, $d = 0.33$, 95% CI [0.20; 0.46]. Privacy was evaluated more often as important as compared to loyal users, $\chi^2(1, N = 524) = 31.32$,

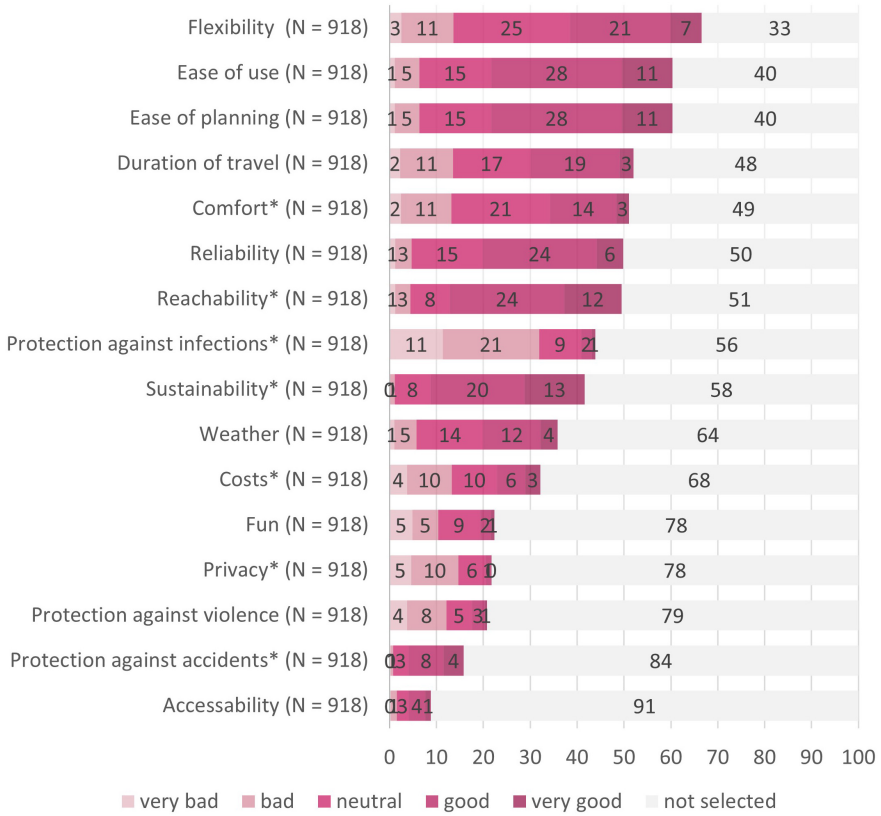

FIGURE 8 | Evaluation of public transport in regards to the importance of different criteria. *N* = 918; Prot. scr., protective screens. Numbers on the bars represent percentages. *Indicates significant differences ($p < 0.003$) between the target groups in selecting this criterion.

$p < 0.001$, $d = 0.38$, 95% CI [0.24; 0.51] and reducers, $\chi^2(1, N = 506) = 10.43$, $p = 0.001$, $d = 0.38$, 95% CI [0.24; 0.51]. To conclude, infection risk was a highly relevant criterion for dropouts to change to other modes of transportation than public transport.

Finally, non-users evaluated comfort and privacy significantly more often as a criterion for transport mode selection as compared to other groups. Comfort was evaluated more often as important as compared to loyal users, $\chi^2(1, N = 412) = 12.47$, $p < 0.001$, $d = 0.23$, 95% CI [0.10; 0.37] and reducers, $\chi^2(1, N = 394) = 8.36$, $p < 0.004$, $d = 0.19$, 95% CI [0.06; 0.32]. Privacy was evaluated more often as important as compared to loyal users, $\chi^2(1, N = 412) = 43.14$, $p < 0.001$, $d = 0.44$, 95% CI [0.31; 0.58] and reducers, $\chi^2(1, N = 394) = 16.68$, $p < 0.001$, $d = 0.27$, 95% CI [0.14; 0.40]. To conclude, non-users did not consider the pandemic as a very relevant issue in their selection of transport mode but focused stronger on aspects of comfort, convenience, and privacy.

Satisfaction With the Criteria of Transport Mode Selection in Public Transport

In addition to the frequency of selected criteria, participants' satisfaction with these criteria in public transport are illustrated in **Figure 8**. The satisfaction of four of the top five criteria of transport mode selection (i.e., flexibility, planning, travel duration, and comfort) by public transport was evaluated as neither good nor bad in the total sample. Ease of use as further top criterion was evaluated as well fulfilled. Public transport received the best five evaluations for ease of use, reliability, reachability, sustainability, protection against accidents, and accessibility; all five factors were evaluated as good. The least well evaluated factors concerning public transport were protection against infections, privacy, and protection against violence, all three were evaluated as bad.

Detailed evaluations of the fulfilment of criteria in public transport, displayed separately for the four target groups, can be found in **Table 4** and is also illustrated in the Supplementary (**Supplementary Figures 1–4**). We looked for differences between the target groups by comparing the medians with 15 Kruskal Wallis tests ($p_{crit} = 0.003$). The results of these omnibus tests and the descriptive statistics can be found in **Table 4** as well. The tests revealed significant differences between one or more groups for all criteria besides accessibility, privacy, and protection against accidences: All four target groups agreed that accessibility and protection against accidents were rather well fulfilled in public transport, whereas privacy was not given.

TABLE 3 | Criteria of transport mode choice as selected by the four target groups.

	Loyal (L) *n* = 193		Reducers (R) *n* = 175		Dropouts (D) *n* = 331		Non-users (N) *n* = 219		Total Sample *N* = 918			
	n	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	χ^2	***p***	***d***
Flexibility of use	114	59	107	61	236	71	154	70	630	11.97	0.007	
Ease of use	128	66	96	55	195	59	135	62	563	5.92	0.116	
Ease of planning	99	51	89	51	212	64	123	56	531	13.25	0.004	
Duration of travel	85	44	91	52	176	53	126	58	490	12.39	0.006	
Comfort*	86	45_{N}	79	45_{N}	180	54	124	$57_{L,R}$	479	14.76	0.002	0.26
Reliability	90	47	100	57	171	52	97	44	467	6.83	0.078	
Reachability*	111	$58_{D,N}$	105	$60_{D,N}$	146	$44_{L,R}$	92	$42_{L,R}$	459	19.96	<0.001	0.30
Protection infections*	45	$23_{R,D}$	79	$45_{L,D}$	197	$60_{L,R,N}$	82	37_{D}	408	69.47	<0.001	0.57
Sustainability*	118	$61_{D,N}$	99	$57_{D,N}$	111	$34_{L,R}$	54	$25_{L,R}$	388	76.67	<0.001	0.60
Weather	67	35	67	38	118	36	77	35	341	0.30	0.961	
Costs*	85	$44_{D,N}$	75	$43_{D,N}$	84	$25_{L,R}$	51	$23_{L,R}$	299	35.20	<0.001	0.40
Fun	37	19	38	22	73	22	57	26	213	3.59	0.309	
Privacy*	14	$7_{D,N}$	26	$15_{D,N}$	89	$27_{L,R}$	71	$32_{L,R}$	206	52.37	<0.001	0.49
Protection violence	28	15	34	19	89	27	40	18	193	13.48	0.004	
Protection accidents*	45	$23_{D,N}$	34	19	44	13_{L}	22	10_{L}	146	16.02	0.001	0.27
Lack of alternatives	27	14	27	15	28	8	28	13	110	6.74	0.081	
Accessibility	21	11	21	12	24	7	15	7	83	4.38	0.223	

**$p < 0.003$ (Bonferroni corrected for the 16 omnibus tests) in the omnibus Chi-squared test. Pairwise group comparisons are based on pairwise two-sided Pearson's Chi-squared test with Yates' continuity correction (Bonferroni corrected $p_{crit} = 0.008$). For each significant difference between the target group in the column header and the other target group(s), the letter of the significantly different group (L, loyal users; R, reducers; D, dropouts; N, non-users) appears as subscript.*

TABLE 4 | Evaluation of criteria regarding public transport evaluated by the four target groups.

	Loyal (L) *n* = 193			Reducers (R) *n* = 175			Dropouts (D) *n* = 331			Non-users (N) *n* = 219			Total Sample *N* = 918				
	n	***Mdn***	***IQR***	***n***	***Mdn***	***IQR***	***n***	***Mdn***	***IQR***	***n***	***Mdn***	***IQR***	***N***	***Mdn***	***IQR***	***H***	***p***
Flexibility of use*	114	$4_{D,N}$	2	107	$4_{D,N}$	1	236	$3_{L,R}$	1	154	$3_{L,R}$	1	611	3	1	90.57	<0.001
Ease of use*	128	$4_{D,N}$	1	96	$4_{D,N}$	1	195	$4_{L,R}$	1	135	$3_{L,R}$	1	554	4	1	106.53	<0.001
Ease of planning*	99	$4_{D,N}$	1	89	$4_{D,N}$	1	212	$3_{L,R}$	2	123	$3_{L,R}$	2	523	3	1	97.22	<0.001
Duration of travel*	85	$4_{D,N}$	1	91	$4_{D,N}$	1	176	$3_{L,R}$	2	126	$3_{L,R}$	2	478	3	2	70.99	<0.001
Comfort*	86	$4_{D,N}$	1	79	$4_{D,N}$	1	180	$3_{L,R}$	1	124	$3_{L,R}$	2	469	3	2	61.07	<0.001
Reliability*	90	$4_{D,N}$	0.75	100	$4_{D,N}$	1	171	$3_{L,R}$	1	97	$3_{L,R}$	1	458	4	1	37.70	<0.001
Reachability*	111	$4_{D,N}$	1	105	$4_{D,N}$	1	146	$4_{L,R}$	1	92	$4_{L,R}$	1	454	4	1	48.32	<0.001
Protection infections*	45_{D}	$3_{R,D,N}$	1	79	2_{L}	1	197	2_{L}	1	82	2_{L}	2	403	2	2	28.25	<0.001
Sustainability*	118	$4_{D,N}$	1	99	4_{N}	1	111	4_{L}	0	54	$4_{L,R}$	1	382	4	1	26.57	<0.001
Weather*	67	$4_{D,N}$	1	67	$4_{D,N}$	1	118	$3_{L,R,N}$	1	77	$3_{L,R,D}$	1	329	3	1	56.70	<0.001
Costs*	85	$3_{D,N}$	2	75	$3_{D,N}$	2	84	$3_{L,R}$	1	51	$2_{L,R}$	1	295	3	2	26.89	<0.001
Fun*	37	$2_{D,N}$	2	38	3_{N}	1	73	2_{L}	1	57	2_{LR}	2	205	3	1	21.19	<0.001
Privacy	14	2.5	1	26	2	1	89	2	1	71	2	1	200	2	1	3.271	0.352
Protection violence*	28	3_{N}	1.25	34	$3_{D,N}$	2	89	2_{R}	1	40	$2_{L,R}$	1.25	191	2	1	27.52	<0.001
Protection accidents	45	4	2	34	4	1	44	4	1	22	4	1	145	4	2	4.63	0.201
Accessibility	21	4	1	21	4	1	24	3.5	1	15	3	1.5	81	4	1	6.59	0.086

*Mdn, Median; IQR, interquartile range. *$p < 0.003$ (Bonferroni corrected for the 16 omnibus tests) in the omnibus Kruskal Wallis test. Pairwise group comparisons are based on two-sided Wilcoxon tests (Bonferroni corrected $p_{crit} = 0.008$). For each significant difference between the target group in the column header and the other target group(s), the letter of the significantly different group (L, loyal users; R, reducers; D, dropouts; N, non-users) appears as subscript. Mdn: 5 = very good, 4 = good, 3 = neither nor, 2 = bad, 1 = very bad.*

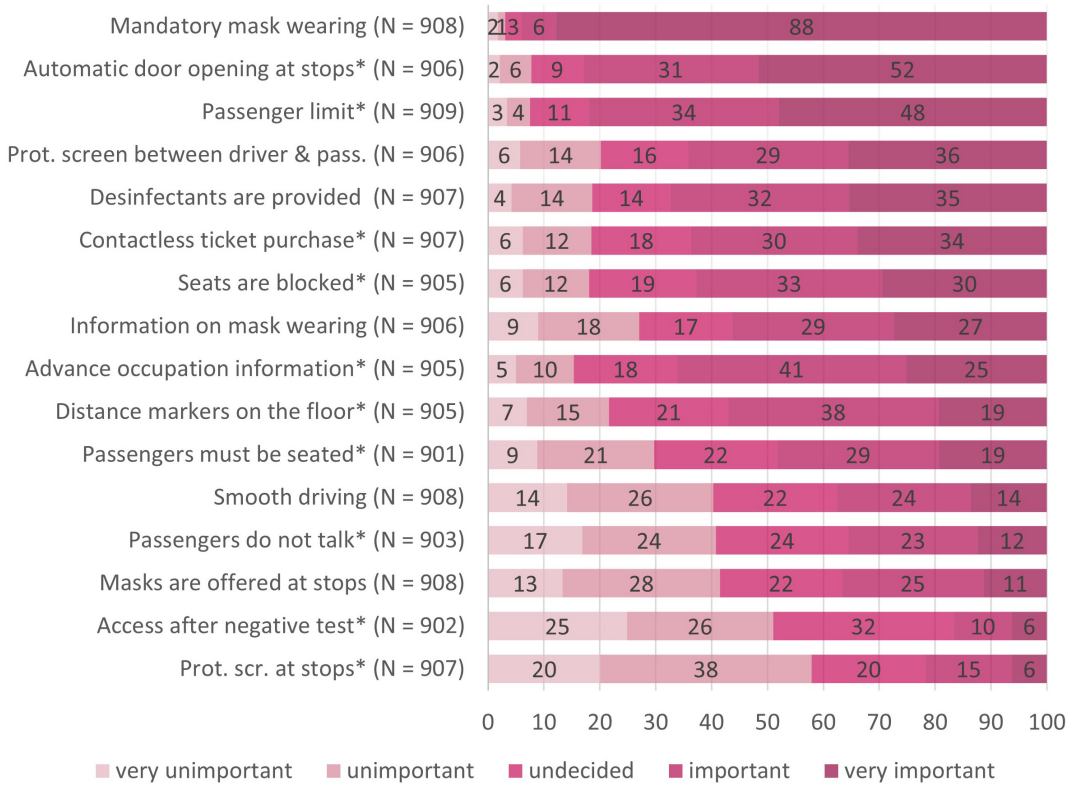

FIGURE 9 | Evaluation of the different measures taken against COVID-19 in public transport. *N* = 918; numbers on the bars represent percentages. *Indicates that significant differences ($p < 0.003$) were found between the target groups in evaluating this measure.

We followed up the significant results with pairwise two-sided Wilcoxon tests ($p_{crit} = 0.008$). The results of these tests can be found as subscripts in **Table 4**. In the following sections we highlight significant differences between the target groups concerning their perceived deficits of public transport.

Loyal users evaluated all criteria either as well fulfilled in public transport as other target groups, or better. Hence, they had a more positive attitude about public transport than all other groups.

Reducers evaluated protection against infections as significantly less well fulfilled in public transport as compared to loyal users, $W = 1286$, $p = 0.007$, $r = 0.24$. All other criteria were evaluated either on the same level fulfilled in public transport, as by other target groups, or better. Hence, reducers too, had a more positive attitude about public transport than those who did not use public transport during the pandemic, but in contrast to loyal users they perceived more deficits in regards to protection against infections in public transport.

Dropouts evaluated flexibility, ease of planning, duration of travel, comfort, reliability, protection against infections, weather, protection against violence and accessibility as less well fulfilled in public transport than other groups: Flexibility of use was evaluated less well as compared to loyal users, $W = 7636$, $p < 0.001$, $r = 0.37$, and to reducers, $W = 8687$, $p < 0.001$, $r = 0.26$. Ease of planning was evaluated by dropouts less well as compared to loyal users, $W = 5064$, $p < 0.001$, $r = 044$, and to reducers, $W = 5965$, $p < 0.001$, $r = 0.30$. Duration of travel was evaluated less well as compared to loyal users, $W = 4108$, $p < 0.001$, $r = 0.39$, and to reducers, $W = 4618$, $p < 0.001$, $r = 0.36$. Comfort was evaluated less well as compared to as compared to loyal users, $W = 4260$, $p < 0.001$, $r = 0.38$, and to reducers, $W = 3983$, $p < 0.001$, $r = 0.37$. Reliability was evaluated less well as compared to loyal users, $W = 5062$, $p < 0.001$, $r = 0.30$ and to reducers, $W = 6488$, $p < 0.001$, $r = 0.22$. Protection against infections was evaluated less well as by loyal users, $W = 2418$, $p < 0.001$, $r = 0.33$. Weather was evaluated less well as compared to loyal users, $W = 2532$, $p < 0.001$, $r = 0.32$, and to reducers, $W = 2032$, $p < 0.001$, $r = 0.43$. Protection against violence was evaluated worse as compared to reducers, $W = 869$, $p < 0.001$, $r = 0.34$. To sum up: Like reducers, participants who had dropped out of public transport during the pandemic perceived protection against infections not only more often as important, but also as less well fulfilled in public transport. In addition, they perceived more deficits than ongoing users, for instance regarding their other most preferred criteria for transport mode selection (i.e., flexibility, ease of planning, travel duration and comfort).

Finally, non-users evaluated flexibility, ease of use, ease of planning, duration of travel, comfort, reliability, protection against infections, weather, costs, protection against violence and accessibility significantly less well than other groups: Flexibility of use was evaluated less well as by loyal users, $W = 4014$, $p < 0.001$, $r = 0.48$, and by reducers, $W = 4014$, $p < 0.001$,

TABLE 5 | Evaluation of the different measures taken against COVID-19 in public transport by the four target groups.

	Loyal *n* = 193			Reducers *n* = 175			Dropouts *n* = 331			Non-users *n* = 219			Total Sample *N* = 918				
	n	***Mdn***	***IQR***	***n***	***Mdn***	***IQR***	***n***	***Mdn***	***IQR***	***n***	***Mdn***	***IQR***	***N***	***Mdn***	***IQR***	***H***	***p***
Mandatory mask wearing	192	5	0	173	5	0	328	5	0	215	5	0	901	5	0	4.95	0.175
Doors open automatically*	191	5_{R}	1	172	$5_{L,D,N}$	1	327	4_{R}	1	216	4_{R}	2	906	5	1	30.12	<0.001
Seats blocked*	189	$3_{R,D,N}$	2	172	$4_{L,D}$	2	329	$4_{L,R}$	2	215	4_{L}	2	905	4	2	50.56	<0.001
Disinfectants are provided	190	4	2	174	4	2	327	4	2	216	4	2	907	4	2	4.21	0.240
Mask information provided	190	4	3	173	4	2	328	4	3	215	4	2	909	4	3	2.79	0.424
Passenger limit*	190	$4_{R,D,N}$	2	175	$4_{L,D}$	1	329	$5_{L,R}$	1	215	4_{L}	1	905	4	1	50.87	<0.001
Distance markers at stops*	191	3_{D}	2	173	4	1	326	4_{L}	1	215	4	1	908	4	1	25.55	<0.001
Screen between driver and pass.	191	4	2	174	4	2	327	4	2	214	4	3	906	4	2	6.65	0.084
Contactless ticket purchase*	190	4_{D}	2	174	4_{D}	2	327	$4_{L,R,N}$	2	216	4_{D}	2	907	4	2	19.77	<0.001
Occupation information*	190	4_{D}	1	175	4_{D}	2	327	$4_{L,R}$	2	213	4	1	905	4	2	19.66	<0.001
Masks can be purchased	191	3	2	173	3	2	328	3	2	216	3	2	908	3	2	0.51	0.917
Passengers must be seated*	191	$3_{D,N}$	2	173	$3_{D,N}$	2	323	$4_{L,R}$	1	214	$4_{L,R}$	1.75	901	3	2	31.19	<0.001
Smooth driving	190	3	2	175	3	2	328	3	2	215	3	2	908	3	2	2.89	0.409
Passengers do not talk*	190	2.5_{D}	2.75	174	3_{D}	2	325	$3_{L,R}$	2	214	3	2	903	3	2	16.27	<0.001
Access only after test*	190	$2_{D,N}$	2	173	2	2	325	3_{L}	1	214	2.5_{L}	1	902	2	1	32.58	<0.001
Protective screens at stops*	191	2_{D}	2	174	2_{D}	1	327	$2_{L,R}$	1.5	215	2	1	907	2	1	17.30	<0.001

*Mdn, Median; IQR, interquartile range. *$p < 0.003$ in the omnibus Kruskal Wallis test (Bonferroni corrected for the 16 omnibus tests). Pairwise group comparisons are based on two-sided Wilcoxon tests (Bonferroni corrected $p_{crit} = 0.008$). For each significant difference between the target groups, the letter of the significantly different group (L, loyal users; R, reducers; D, dropouts; N, non-users) appears as subscript under the median. For each significant difference between the target group in the column header and the other target group(s), the letter of the significantly different group (L, loyal users; R, reducers; D, dropouts; N, non-users) appears as subscript. Mdn: 5 = very important, 4 = important, 3 = neither nor, 2 = unimportant, 1 = very unimportant.*

$r = 0.14$. Ease of planning was evaluated less well than by loyal users, $W = 2375$, $p < 0.001$, $r = 0.55$, and reducers, $W = 2928$, $p < 0.001$, $r = 0.16$. Duration of travel was evaluated less well as by loyal users, $W = 2908$, $p < 0.001$, $r = 0.41$, and reducers, $W = 3260$, $p < 0.001$, $r = 0.39$. Comfort was evaluated less well as by loyal users, $W = 3432$, $p < 0.001$, $r = 0.32$, and reducers, $W = 3247$, $p < 0.001$, $r = 0.30$. Reliability was evaluated less well as by loyal users, $W = 2729$, $p < 0.001$, $r = 0.35$, and reducers, $W = 3522$, $p < 0.001$, $r = 0.26$. Protection against infections was evaluated less well as by loyal users, $W = 1182$, $p = 0.004$, $r = 0.31$. Weather was evaluated less well as by loyal users, $W = 1464$, $p < 0.001$, $r = 0.39$, and reducers, $W = 1140$, $p < 0.001$, $r = 0.51$. Protection against violence was evaluated less well as by loyal users, $W = 297$, $p = 0.006$, $r = 0.41$, and reducers, $W = 295$, $p < 0.001$, $r = 0.50$. To sum it up, non-users perceived more deficits in public transport as compared to ongoing users (i.e., loyal and reducers) in terms of their most important criteria flexibility, ease of use and planning, travel duration and comfort, but also for infection risk which was however not that important for transport mode selection in this group.

Evaluation of Measures Taken in Public Transport to Decrease the Infection Risk

Figure 9 gives an overview of the participants' evaluations of the fifteen measures taken against COVID-19 transmission in public transport. The top ranked measures were wearing the mask and doors open automatically at stops, being both evaluated as very important. Participants evaluated as important that one seat is blocked in between, disinfectants are provided, information about mask wearing is provided, passenger limit, distance markers at stops, screens between drivers and passengers, contactless ticket purchase and access to advanced occupation information. The measures evaluated as unimportant were access to public transport only with negative test and protective screens at the stops. In summary, measures that maintained social distance and fresh air in public transport were rated as particularly important by the sample.

A summary of the four target groups concerning their evaluations of sixteen measures against COVID-19 transmission in public transport can be found in **Table 5** and is furthermore illustrated in the Supplementary (**Supplementary Figures 5–8**). Kruskal Wallis tests ($p_{crit} = 0.003$) (see **Table 5**) revealed no differences between the four target groups concerning the evaluation of mandatory mask wearing, providing disinfectants, information about masks, screen between driver and passenger, masks can be purchased, and smooth driving. However, significant differences between the target groups were found in the evaluations of automatic door opening, seats blocked, passenger limit, distance markers, contactless ticket purchase, occupation information, passengers must be seated, passengers do not talk, access only after test and protective screens at stops. We followed up the significant results with pairwise two-sided Wilcoxon tests ($p_{crit} = 0.008$). The results of these tests can be found as subscripts in **Table 5**. In the following sections we highlight significant differences of preferences between the target groups:

Loyal users did not evaluate any measure against COVID-19 transmission in public transport as significantly more important that other groups.

Reducers, in contrast, preferred automatic door opening and blocked seats significantly more than other target groups: Automatic door opening was preferred more than by loyal users, $W = 19044$, $p = 0.003$, $r = 0.16$, than by dropouts, $W = 22888$, $p < 0.001$, $r = 0.17$, and non-users, $W = 13208$, $p < 0.001$, $r = 0.27$. Blocked seats were perceived as more important than by loyal users, $W = 19080$, $p < 0.001$, $r = 0.15$. In sum, reducers evaluated measures that were directly experienceable within the vehicle as significantly more important than other groups.

Dropouts evaluated blocked seats, a passenger limit, distance markers at stops, passengers must be seated, passengers do not talk and entrance after test significantly more important than other groups: Blocked seats were evaluated as more important than by loyal users, $W = 42054$, $p < 0.001$, $r = 0.31$. A passenger limit was evaluated as more important than by loyal users, $W = 42016$, $p < 0.001$, $r = 0.31$ and by reducers, $W = 32682$, $p < 0.001$, $r = 0.12$. Distance markers at stops were evaluated as more important than by loyal users, $W = 42016$, $p < 0.001$, $r = 0.22$. Passengers must be seated was evaluated as more important than by loyal users, $W = 38290$, $p < 0.001$, $r = 0.21$, and reducers, $W = 33034$, $p = 0.005$, $r = 0.16$. Passengers do not talk was evaluated as more important than by loyal users, $W = 39778$, $p < 0.001$, $r = 0.21$. Entrance after negative test was evaluated as more important than by loyal users, $W = 39778$, $p < 0.001$, $r = 0.25$. In sum, dropouts perceived most measures against the pandemic as important and differed from other groups especially regarding their evaluation of a passenger limit as very important and of distance markers at stops as important. Hence concerns about crowding seemed to be a very important criterion for dropping out of public transport during the pandemic.

Non-users evaluated blocked seats, passengers must be seated, and access after test, as significantly more important compared to other groups: Blocked seats were perceived as more important than by loyal users, $W = 25374$, $p < 0.001$, $r = 0.22$. Passengers must be seated was evaluated as more important than by loyal users, $W = 25173$, $p < 0.001$, $r = 0.21$. Access after test was evaluated as more important as compared to loyal users, $W = 24201$, $p = 0.006$, $r = 0.17$. In sum, non-users also perceived many measures against the pandemic as important. They differed from other groups concerning their positive evaluation of access after tests and mandatory seating in vehicles.

DISCUSSION

In this study, we aimed to understand passenger reductions in public transport during the pandemic and sought leverage to bring people (back) to public transport after the pandemic. We initially quantified changes in public transport use during the pandemic in a representative sample of a German major

city. Within this sample, we found differences between the target groups of pandemic public transport usage (i.e., loyal users, reducers, dropouts and non-users) regarding (1) their perceptions of infection risk, (2) their general preferences for mobility and these preferences' fulfilment in public transport, and (3) their evaluations of measures taken by public transport suppliers against the pandemic.

In line with other studies (Finbom et al., 2020; Shibayama et al., 2021; DLR Transport, 2022a,b), we observed in our representative sample a general mode shift from public transport to walking, car usage, and bicycling during the pandemic. In our sample, only 21% kept on using public transport, 19% reduced public transport usage during the pandemic, 36% dropped out of public transport, and 24% remained general non-users of public transport.

Overall, we found participants to perceive a high infection risk in public transport. This increased perception of infection risk stands in contrast to other considerations (Sommer et al., 2021) that the objective infection risk is rather low in public transport, considering the short contact duration, the effective fresh air ventilation systems in and the fact that mask wearing has become the new norm. Participants hence tended to overestimate the infection risk for public transport in comparison to other situations. Looking at the different target groups, reducers, dropouts, and non-users perceived an increased (i.e., high) infection risk for public transport in comparison to loyal users. It is important to note that these differences in risk perception between groups were specific to public transport and did not generalize to comparable day-to-day situations, such as going to work, or to the grocery store. These findings are in line with Finbom et al. (2020), who found lower risk perception in users as compared to non-users, and with Sadique et al. (2007) who reported that even though a person's perceived risk for influenza had little effect on their everyday lives, it did affect public transport usage. These findings allow for two possible explanations. First, an increased infection risk perception, specific to public transport might have caused reductions and dropouts of public transport during the pandemic. Second, people who stuck to public transport (because they had to do so, or because they wanted to) had the opportunity to experience that measures against the pandemic were also taken in public transport, that public transport was quite empty during the pandemic, or that, even though they used public transportation, they were not infected more often than others. These experiences might have resulted in a lower infection risk perception in the group of ongoing users. Both explanations, however, imply that decreasing the objective and subjective infection risk in public transport should be prioritized in order to (re-)attract passengers during the ongoing pandemic and in the future.

Looking at general criteria of transport mode selection during the pandemic, flexibility, ease of use, ease of planning, and travel duration were the top criteria for transport mode selection in all target groups. Loyal users however distinguished from other groups by a stronger consideration of sustainability, reachability, and costs. In the same vein, reducers selected their transport mode more often based on sustainability, reachability, and costs, but they rated (an insufficient) protection against infections as important, too. For dropouts this factor of (an insufficient) protection against infections was particularly often relevant, in addition to privacy. In contrast to that, non-users showed a stronger preference of comfort and privacy as compared to all other groups. Infection risk was thereby not very informative of their transport mode selection. Furthermore, participants in all four target groups agreed that reliability, reachability, and sustainability were well fulfilled by public transport, and that privacy was not fulfilled. A central finding in our representative sample was that reducers as well as dropouts and non-users perceived more deficits regarding protection against infections than loyal users. To sum it up, especially in the group of reducers and dropouts, protection against infection was a relevant criterion to reduce or quit public transport usage during the pandemic, especially as this factor was perceived as not well fulfilled in public transport by these groups.

Looking at participants' evaluation of the measures taken in public transport against the pandemic, mandatory mask wearing was evaluated as the topmost important measure to feel safe in public transport during the pandemic in all four groups. In addition, reducers regarded automatic door opening very important and thereby more important than all other groups. Dropouts perceived a passenger limit as very important, and regarded blocked seats, distance markers as stops, mandatory seating, and access with negative test as more important measures than other groups. Non-users perceived blocked seats, mandatory seating, and access with negative test as more important measures than other groups.

Finally, we found ongoing public transport users (i.e., loyal users and reducers) to be on average younger, more often students, being more likely to have no access to alternatives to public transport, or simply preferring public transport as compared to non-users. Non-users (i.e., pandemic dropouts and non-users) were on average older, more often employed, had more often access to alternatives to public transport or no access to public transport. The differences in socio-demographic support the findings of Finbom et al. (2020) that context factors, such as dependency on public transport, access to public transport, occupational status, as well as participants age (and accordingly their objective risk to suffer severely from a COVID-19) determined transport mode selection during the pandemic as well, and that these factors should be considered when planning to (re-)attract these groups. Contrarily to Finbom et al. (2020), we did not find any differences in the financial statuses of non-users and users.

Practical Implications for Communication in Public Transport

Since the beginning of the pandemic, there have been intensive discussions about how to win back passengers and make public transport more resistant to pandemics. In the following section we will discuss communicative interventions to decrease the objective and subjective risk in public transport during the pandemic with a focus on the four target groups described in

this paper. Our thoughts are based on the summary of behavioral change techniques of Contzen and Mosler (2015).

Using Communication to Decrease the Objective Risk in Public Transport

In the dynamic setting of the pandemic, targeted communication can play an important role in communicating the state-of-the-art knowledge about the most important measures, and to guide desired behavior in passengers of public transport. In the beginning of the COVID-19 pandemic, when it was yet unclear how the virus was transmitted, prompting the population to stay at home was an important communicative measure to decrease the objective risk in public transport, in particular because following the recommendation of keeping 1.5 m distance could only be fulfilled when occupation was low (McKinsey and Company, 2020). At the current moment, findings suggest that masks – especially FFP2 masks – are a very effective tool for decreasing infection susceptibility, even in crowded public transport (Chu et al., 2020; Ueki et al., 2020; Bagheri et al., 2021; Will et al., 2021). As long as recommendations concerning mask wearing, social distance and hygiene measures are followed by all passengers of a public transport, passengers thus could travel safely.

Loyal users and reducers are the main target groups, for communication addressing compliance with hygiene regulations within public transport. Even before entering public transport, they should be informed about digital measures of social distancing, such as the occupation tool and the option of contactless ticket purchase. As these instruments were newly implemented in public transport in many cities, customers need to be informed about the existence of these new options and first attempts in using these tools could be supported by instructional aids, or demonstrations. Trying out these tools could be prompted in a planning app, but other means of mass communication might be valuable tools of communication additionally. At stops and within the vehicle, nudges (e.g., distance markers on the floor) can be used to avoid crowding. Information about the correct do's and don'ts in public transport should be communicated in a clearly visible fashion in the vehicles, but also outside of the vehicles to allow passengers to take the necessary preparations before entering (e.g., putting on the mask). Our findings show that all groups considered mandatory mask wearing as very important measure to feel safe in public transport. Prompting to wear the masks might thus seem a bit like preaching to the converted, but this measure is still important in order to establish correct mask wearing as the new norm and to prevent social loafing (Simms and Nichols, 2014). Passengers could thereby be informed of the increased protection of FFP2 masks in comparison to other medical masks. In addition, personal norms and self-efficacy belief could be activated. Thereby, loyal users (who did not perceive an increased risk in public transport) might profit more from a message focusing on altruistic values (e.g., "I wear the mask to protect others," or "for others to feel safe"), or messages communicating mask wearing as a precondition to help public transport to keep on fulfilling its role as sustainable infrastructure even through the pandemic (e.g., "I am green! From mask to transport mode," "I wear the mask to keep public transport working"). In contrast, reducers might be more receptive to a message highlighting their self-efficacy (e.g., "with the FFP2 mask I am safe"). When thinking about the new norm in public transport, it should also be considered that dropouts and non-users (re)entering public transport after a long time, or even for the first time, need to be informed about the altered regulations and the new normal of public transport in advance, to avoid drawbacks caused by a feeling of unfamiliarity or unpreparedness. Offering masks at the stations might be especially valuable for these groups. Furthermore, the study of Huu Manh et al. (2021) suggests that communication does not end with only wearing the mask, but also prompting to wear masks correctly could contribute to decreasing the objective risk in public transport. In their study, 11% of passengers failed to wear the mask correctly, especially passengers who were older, rarely used public transport, transported heavy luggage, or traveled with others. The study of Bagheri et al. (2021) highlights the additional value of wearing the mask correctly and the knowledge of how to do so should thus be communicated at the entrance of vehicles as well. In the same vein, providing disinfectant could be accompanied by prompts to use it and how to use it correctly. As reducers and dropouts in our study reported higher preference of measures that increased distance, it might also be helpful to find out which spaces in vehicles are the safest and to communicate these areas during a pandemic (or restrict access to risk groups).

Decreasing the Subjective Risk in Public Transport

Our findings show that public transport urgently needs to regain trust and the reputation of being a safe space after 2 years of the pandemic. Participants in our sample – especially reducers, dropouts and non-users – had an increased perception of infection risk that was specific to public transport. An important pre-condition for regaining public trust is of course to know about the objective infection risk in public transport and implementing the most effective measures to decrease it. However, technical solutions *per se* will not be enough. Insights from aerosol simulations that were conducted within our research project indicate that the filtration systems in public transport vehicles are very efficient, even though not directly experienceable for passengers (EMILIA Findings with ESI Group, 2021). Such findings on the objective infection risk should be communicated publicly, to adjust public perceptions of public transport. It is interesting to note that, according to our simulations, additional automatic door opening – though strongly preferred by ongoing users of public transport in our sample – only have a marginal additional effect (max. 10%) as compared to ventilation only and for that reason have more value as an instrument for decreasing the subjective risk perception (EMILIA Findings with ESI Group, 2021). This example shows that the most important objective measures are not always perceived accurately by passengers. Targeted communication might play an important role in adjusting risk perceptions and the evaluation of certain measures.

Loyal users and reducers could thereby potentially take on the important roles of knowledge multipliers for other target groups. Measures taken should therefore be highlighted and, where necessary, explained to passengers. Fact sheets on infection risks in relation to different measures/scenarios could support communication, as well as simulations, e.g., illustrating air exchange within the vehicle, might play an important role in showing the unseen measures taken in public transport and to increase self-efficacy. As we have found that loyal users and reducers perceive automatic door opening as a very important measure (even though the efficacy of this measure is limited according to scientific evidence), the underlying concern of getting fresh air into the vehicle can be taken as an opportunity to communicate the effectiveness of the ventilation system, which already brings fresh air into the vehicle (i.e., "you do not have to freeze for fresh air"). Once users of public transport have noticed which measures are taken in public transport and why they are taken, they can be prompted to speak with others about these measures to increase descriptive norms of using public transport within the pandemic. A creative way of transporting new behavioral norms of public transport to other groups, might be for instance to distributing masks as incentives and starting a photo competition with these masks in public transports. Within the vehicle one should keep in mind to only communicate measures that are possible to fulfill (e.g., unlike the often-seen recommendation of hand washing, which is simply not fulfillable in busses and trams) to maintain self-efficacy. In order to create a new image of public transport as a safe and hygienic space it might also be useful to perform hygiene measures that are very visible and experienceable for passengers (e.g., cleaning the surfaces, opening the doors automatically) as a mean of communication in itself.

The most challenging task will however be regaining the trust of pandemic dropouts. This group might have already established new habits and has had no opportunity to perceive the measures taken during the pandemic since it has fully avoided public transport. An important precondition to reattracting this group will be to create a new image of public transport. Public transport should transparently communicate about and reattribute past failure ("We were not prepared – now we are!") and actively communicate what has been learned during the pandemic and which measures were taken to increase safety from infections and how they can be used (e.g., the occupation tool, new behavior rules). To disrupt the new habits of pandemic dropouts and creating opportunities to make new experiences in public transport, special discount campaigns (e.g., a ticket for free to experience the "new hygienic" public transport) might be useful to entice this group. However, these incentives should be guided by communication on measures against infection risk in public transport (e.g., with factsheets about the effectiveness of masks). A good idea might also be the active signaling of personal values, such as "We care about your health." A very creative idea to signal personal values while creating opportunities for new experiences in public transport was for instance to invite passengers for a free ride to their vaccination (Steeger, 2021). Former subscribers could be contacted *via* letter, and other dropouts could be reached *via* mass media and *via* outdoor advertising, e.g., on the surface of the vehicles (e.g., stickers, highlighting the well ventilation inside). It should however be taken care that a positive group identity can be established in this group (e.g., "We are the comebacks of 2022!", or "Boostered and back on the road"). It might also be important to anticipate and prompt coping with relapses and barriers when coming back ("If you feel unsafe, contact us!", or "If you feel unsafe, wear your FFP2 mask – you will be safe!").

Non-users could be attracted with conventional means of communication and incentives. They were not so much concerned about protection against infections, but rather concerned about comfort in public transport. This aspect should certainly be a part of communication when attracting this group, such as highlighting how convenient it is to drive to the city center without needing to search for a parking spot. In addition, attitudes regarding other factors such as flexibility, ease of use and planning, and travel duration could be altered. Distributing "A beginners guide for public transport after COVID-19," including advice on behavior and hygiene but also showing example routes, comparing travel durations for bus and car including the search for parking spots, and providing how-to knowledge on public transport usage, ticket purchases and so on could be a successful mean of communication. In addition, incentives of free rides should also be combined with information on how to comfortably use the ticket, e.g., when linked with a specific event, an example route could be already planned out. Also, for the group of non-users, barrier planning, and coping should be taken into consideration by providing information on where to look if a vehicle is too late, where to enter to find a free seat, etc.

Taken altogether, a great variety of tailored measures are conceivable in order to bring people (back) to public transport, measures that take the specific characteristics of the different target groups into account, as derived from our study.

Strengths and Limitations

In this study, we investigated public transport usage during the pandemic through a multifaceted lens. In contrast to other studies in the field, we managed to shed a light on the perspective of pandemic dropouts and non-users as well by recruiting a representative sample of a German major city. Our findings focus on risk perception during the pandemic, but we also go one step further in seeking and finding leverage points to (re-)attract passengers *via* targeted communication and to make public transport resilient to upcoming pandemics. Our findings are limited however by the focus on an urban setting and our findings should always be interpreted in context of the third wave and the second lockdown (Kodzo and Imöhl, 2022) in which we conducted our sampling. At the time of the survey the vaccination rate was furthermore still on a low level which likely influenced risk perception.

CONCLUSION

Within the pandemic, the largest advantage of public transport – moving many people at once in a dense space – became its largest disadvantage and caused a great reduction in public transport

usage. Even despite the changed pandemic conditions (especially in terms of scientific findings, higher vaccination rates, reopened destinations, and non-lockdown-phases), the demand for public transport has not yet recovered. The forecasts for the future of public transport also look poor: An increase in working from home is also expected beyond the duration of the pandemic. It is expected that about one-third of all appointments away from home could now be virtual. As a result of this development, it is assumed that work mobility will experience a decline of 5.5–8% in Germany (Richert et al., 2021). Only 64% of respondents said they would use public transport in the future as they did before the COVID-19 pandemic. Currie et al. (2021) predict that infection fear will remain influential in transport mode selection even after the pandemic. However, public transport is needed as a strong backbone for public services and as an important part of the transformation of the transport sector toward a sustainable mobility that is accessible and feasible for all people around the world. To achieve the climate targets and to enable mobility for all, the above-mentioned trends must be reversed as quickly as possible. Strengthening local public transport, which is indispensable for the transformation of the mobility sector, is a long way off and decrease of passengers will not reverse itself. Public transport therefore quickly needs to get used to a post-pandemic "new normal." The study highlights that the topic of risk perception will play an important role in attracting new and former passengers within this "new normal" and reveals starting points for interventions and development toward a future pandemic-resistant public transport.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants or their legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

AH conducted the data analysis and wrote and revised the manuscript. MR conceptualized and conducted the survey and drafted the data analysis and the methods section. NS conceptualized and conducted the survey and wrote the public transport specific parts in the introduction and in the discussion. AH, MR, and NS jointly interpreted and discussed the findings. ME supported AH during the writing process by providing feedback and suggestions regarding different versions of the manuscript. CS supported AH, MR, and NS throughout the planning and conceptualization of the study and by providing feedback and suggestions regarding different versions of the manuscript. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.926539/full#supplementary-material

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The Psychological Impact of Global Education Approach to SDGs. A Study on Emotions and Sustainability Attitudes of European Teachers

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In line with the international policies, Global Education (GE) programs have been widely spread in European schools over the last 20 years, in order to promote environmental and social sustainability and the achievement of the Sustainable Development Goals. Despite this popularity, their effects on attitudes and behaviors have been poorly investigated so far, particularly for teachers. Our study addressed this research gap analyzing the psychological impact of an extensive GE project involving 1,303 teachers from 10 European countries. Relevant changes in teachers' emotional states and attitudes toward sustainability and migrations were analyzed through a pre-post experimental design. Results showed that the GE activities had wide positive effects on teachers, reducing their negative emotions after teaching, increasing their attitudes about sustainability, and mitigating negative attitudes toward migrants. No significant impacts on positive emotions have been detected. Educational and methodological implications of the applied psychological assessment are finally discussed.

Keywords: Global Education, SDGs, emotions, sustainability, sustainability attitudes, migration attitudes, sustainability assessment, social psychology

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INTRODUCTION

The worldwide achievement of pro-environmental and sustainability goals was increasingly connected with the educational field over the past half century, as the link between education (in formal and non-formal settings) and the progressive spread of sustainable attitudes and behaviors in society has been gradually integrated into local and international policies, until it became a crucial point. This evolution was consistent with the progressive, although not linear, adoption of more systemic global policy models on environmental conservation, which integrated the economic, social and cultural components through the wider concept of sustainability (Caradonna, 2014). A close correlation between the educational dimension, environmental protection and behavior was first promoted on a global policy scale by the Tbilisi Declaration (UNESCO-UNEP., 1978), which included the creation of "new patterns of behavior of individuals, groups and society as a whole" among the main objectives of environmental education (EE), along with strengthening awareness, attitudes and values directed toward the biosphere preservation. Later, Agenda 21 [United Nations (UN), 1992] defined education as critical in improving the capacity of the people to address environmental issues, and indispensable in modifying people's attitudes in order to strengthen their abilities to cope with their sustainable development concerns. Accordingly, the most recent global policy frameworks [e.g., The 2030 Agenda for Sustainable Development, target

4.7; United Nations (UN), 2015] stated that education has an even more crucial role, as they no longer attributed to it the purpose of supporting individual attitudes and behaviors only, but of starting up real sustainable lifestyles at a societal level. Furthermore, new education approaches, the commitment to SDG 4 (i.e., quality education, which means ensuring inclusive and quality education for all and promoting lifelong learning) and the reconceptualization of education as a means for people's wellbeing and global development were included among the key issues for an effective sustainable agenda (UNESCO, 2016).

In parallel with the progressive integration of the educational issues into increasingly systemic policy models, also significant changes in the educational frameworks on environment have been observed. The initial approach based on Environmental Education (EE), focused on protecting and enhancing natural environments, has been integrated since the 90's by the introduction of the Education for Sustainable Development (ESD; UNESCO., 2005) framework, oriented toward a greater consideration of the economic, social and development dimensions (McKeown and Hopkins, 2010). According to Pauw et al. (2015), ESD-oriented programs have significantly contributed to increase awareness and skills toward sustainable development in students and the general population, where applied. In partial disagreement, other scholars offered less optimistic conclusions, both as regards the general diffusion of a systemic concept of sustainability (Sonetti et al., 2021; Norton et al., 2022), and for the applied monitoring methodologies (O'Flaherty and Liddy, 2018). Regarding attitudes and behaviors, the success of EE and ESD programs was also found to be closely connected to the emotional dimension. In his classic review, Iozzi (1989) stressed the need for greater integration of the emotional domain in school curricula, to encourage a greater effectiveness of environmental education. Later, this link was experimentally tested by several studies (Tsevreni, 2011; Russell and Oakley, 2016), confirming its efficacy. More in general, Pooley and O'Connor (2000) pointed out the crucial role of emotions in developing pro-environmental attitudes, independently and in synergy with beliefs. Accordingly, some scholars (Thomas et al., 2009; Robina-Ramírez et al., 2020) have emphasized the effectiveness of environmental and prosocial emotions in promoting concrete actions of sustainable transformation through *ad hoc* educational programs.

Although the ESD approach has also been criticized for its anthropocentrism (Kopnina, 2014), research and educational activities in this field have been found (Ardoin et al., 2013) to gradually evolve toward a growing consideration for the community dimensions and for the intersections between ecological and social issues. In this scenario, the Global Education (GE) approach to sustainability has recently emerged, in response to the risk of an excessive focus on purely ecological issues, unrelated to a proper advancement of social justice and democracy (Scheunpflug and Asbrand, 2006). GE faced a long evolution since its origins (see Hanvey, 1976), giving origin to a rich debate on its definition and the resulting educational approaches. Pike and Selby (1995) proposed a four-dimensional model which stresses GE's holism, as the educational process takes place in the interaction between four dimensions: spatial, psychological (inner), temporal and issue-related. Similarly, Long (2013) advanced a model consisting of three main dimensions: epistemic (systemic perspective and interconnectedness), psychological (connecting world and personal identity) and civic (global citizenship and local action). The Maastricht Declaration, drafted by the Council of Europe (2002), stated that "Global education is education that opens people's eyes and minds to the realities of the globalized world (...). Global education is understood to encompass Development Education, Human Rights Education, Education for Sustainability, Education for Peace and Conflict Prevention and Intercultural Education; being the global dimension of Education for Citizenship." Later, a review (Young, 2010) of the existing GE projects argued that various approaches coexist under this label, mainly focused on interculture, civic action and ecology respectively. Accordingly, Ferguson Patrick et al. (2014) stated that GE can be conceived as an approach aiming to enable youth to participate in creating a shared future for the world, by highlighting the strong interdependence of the human community. Hence GE implies the valorization of cultural diversity, human rights and sustainable development: the environmental issues are considered as integrated in a broader societal framework. A good summary of the GE principles was provided by the guidelines of the Council of Europe (2008), updated in 2019), as eight methodological pillars (e.g., holism, problem-orientation, citizens' participation) and seven main issues, including Environmental Education, have been highlighted. Some scholars consider such holistic view of GE consistent with a shift from an anthropocentric philosophy to a biocentric philosophy, which establishes a life-centered perspective emphasizing the intertwining between humans and the environment as "the culture is in the final analysis grounded in nature" (Selby, 2000, p. 89). According to this approach, including the cultural dimension in GE means recognizing the link existing among all forms of oppression, being it toward human or not-human forms of life (e.g., racism, classism, speciesism), which reinforce each other (Gaard, 1993). The relevance of the cultural factors for GE goes back in time, as international understanding (i.e., accurate knowledge of other cultures to favor friendly relationships among countries) and multicultural education (i.e., sympathetic comprehension of the different cultures in current societies, increased by migrations) can be considered among the predecessors of GE (Fujikane, 2003). Such issues, promoted since the 40's and the 60's respectively, gradually lost popularity at both national and international levels and reached an impasse which prevented them from becoming key issues in shaping school curricula. However, since the 90's the emphasis on the more complex notion of global dynamics, rather than international, and the need to stress the interdependency also in the ecological field favored the integration of cultural issues into the wider GE approach. The relevance of cultural factors for sustainability education led to the notion of intercultural sustainability: intercultural communication and relations are seen "as an essential dimension of the discourse on global sustainability" (Busch, 2016, p. 63), including various fields such as migrations, language teaching or conflict management.

Despite the widespread popularity of educational projects inspired by the GE framework, few research have so far systematically investigated its impacts on the competences of students, and even less on teachers. Regarding students, a substantial convergence of scholars on positive impacts can be highlighted, despite the variety of contexts and applied methodologies. Research (DeNobile et al., 2014) on a sample of Australian students involved in GE-based courses found significant pre-post changes in values and attitudes on some specific dimensions: personal identity (strongest impact), social justice, community membership, environmental sustainability. Conversely, no significant changes were detected on other factors (e.g., empathy, shared emotional connection). Focusing on attitudes toward international development and sustainability, a UK survey (Hogg and Shah, 2010) was conducted by comparing the responses of those who had GE-based learning at school and those who did not. Results showed that the former are considerably more inclined to give a positive contribution to change through social actions, more comfortable with racial and religious diversity, more concerned with sustainability and poverty issues.

Less attention was devoted to the effects of GE on teachers. Most of the studies focused on the motivational factors that lead them to choose such an approach (Biberman-Shalev, 2021) and on the importance that they attribute to it within the students' school curricula (Holden and Hicks, 2007). Another well-covered topic is related to the teachers' training needs, as significant deficiencies in this regard were often highlighted (Mundy and Manion, 2008; Reysen and Katzarska-Miller, 2018). In this regard, it is also relevant to mention the growing body of research on "teaching sensitive issues," as it often underlines the perceived lack of preparation by teachers in managing the social and ideological conflicts inherently linked with controversial topics, as those usually addressed by GE (Kello, 2016; Savenije et al., 2019). Previous studies therefore focus on the systemic or antecedent aspects of GE-based educational activities, while, to our best knowledge, no research has so far been focused on the impact of the latter on teachers' attitudes toward sustainability and other concepts related to GE. Furthermore, despite many studies on the psychological state of teachers during teaching in general (e.g., Beer and Beer, 1992; Postareff and Lindblom-Ylänne, 2011), the emotional condition of teachers associated with GE activities has never been investigated so far. Few studies (Boler, 1999; Tallon, 2012) investigated a similar topic, namely how teachers use emotions as an educational tool in the GE context, emphasizing that altruistic emotions such as pity, compassion and guilt are frequently used to manage the class, with the possible side effect of generating forms of passive empathy unable to encourage action for social change among students.

Our study addressed this research gap by analyzing the psychological effects of being part of a common GE project on more than a thousand high school teachers from 10 European countries. In detail, the emotional states of teachers after GE activities in comparison with those experienced after standard school activities were analyzed, as well as any significant changes in their attitudes toward sustainability (in a broader sense) and migrants (as a component of intercultural sustainability relevant in contemporary school contexts, in light of the issues included in the current case study) through a pre-post experimental design. The following hypotheses are tested to identify a positive psychological impact of GE activities on teachers:

Hp. 1: After GE activities, teachers will show a decrease in negative emotions associated to teaching compared to standard lessons.

Hp. 2: After GE activities, teachers will show an increase in positive emotions associated to teaching compared to standard lessons.

Hp. 3: Positive attitudes toward sustainability will show a significant increase after GE activities, in comparison with the baseline data.

Hp. 4: Negative attitudes toward migrants will show a significant decrease after GE activities, in comparison with the baseline data.

METHOD

Participants

The current research is part of the DEAR (Development Education and Awareness Raising) European Project "Start the change!", a GE-based project involving 12 European countries (Austria, Croatia, Czech Republic, France, Germany, Italy, Malta, Poland, Slovakia, Slovenia, Spain, United Kingdom). The aim of the project is to improve the educational offer consistently with the GE approach and contribute to the achievement of the SDGs by 2030, devoting particular attention to the relationship between climate change, migration, and global inequality. The main targets are youngsters 15–24 years old and secondary school teachers. The outcomes foresee: (1) design and implementation of educational activities on the relationship between SDGs and migrations; (2) creation/strengthening of innovative forms of youth participation in local communities; (3) building a network among schools, civic organizations, and local institutions for public awareness campaigns. The involved schools invited their teachers to attend a training phase and then to follow an applied phase to put the GE principles into practice during teaching activities focused on the issues of the project. The participation in both phases was completely voluntary, and teachers could attend the training even without implementing applied activities with students. A convenience sampling was done on the participants, only data from teachers attending both phases are considered in this study. A total of 1,311 teachers from 323 schools attended the training and 1,292 filled in the questionnaire before the attendance (98.6%), whereas 378 completed the questionnaire after concluding the activities with the students (29.3%). The current paper presents the data regarding the impact on upper secondary school teachers (ISCED 3), including teachers from 10 countries (Austria, Croatia, Czech Republic, Germany, Italy, Poland, Slovakia, Slovenia, Spain, United Kingdom), referred to a total population of 1,773,427 teachers in the European Union – 28 countries (EU-28) in 2019 (Eurostat, 2022). The average age of teachers was 43.76 years, with an average teaching experience of 14.91 years. This is consistent with data showing older populations for higher levels of education, as at ISCED 3 in

EU-28 39% of teachers are aged 50 or more (Farrugia et al., 2020). The sample appears to be unbalanced by gender (82.2% women, 17.5% men, 0.3% not binary), but substantially in line with the current employment data, as according to Eurostat (2020) many of the participating countries have a percentage of female teachers in upper secondary schools between 70 and 80%.

Procedure and Materials

To evaluate the effects of participating in the GE program, a longitudinal quasi-experimental study was designed. The GE program was coordinated by the project leader and locally implemented by the partner NGOs working with the schools and in charge of training the teachers. The program included two main phases for all the participants. The first phase was an intensive training for teachers, organized by NGOs on the issues of GE, SDGs and migration, including methodological issues for applying those principles into daily teaching; the duration of this phase was homogeneous across the countries. The second phase led them to design specific activities carried out in the following months, connecting the topics faced during the training with the specific subject taught by each teacher; the duration of this phase was subject to variations due to the school calendar of each country, yet in most cases it lasted around one school year. All the data presented in the current study are collected from teachers who completed both phases. Teachers filled in two questionnaires, the first before attending GE courses, the second at the end of their activities with students applying the GE principles. The questionnaires were administered both through paper and pencil and digital formats, according to contextual availability in the schools involved in the project. The data collection process was divided into three annual periods (2018–2020) consistent with the timing of the school years, with the first administration in the months of September-October and the second in May-June.

The measures presented through the questionnaire included:

1) Socio-demographic variables (age, gender, country of residence).

2) Emotional state when teaching, with an adapted version of the PANAS (Watson et al., 1988). The scale used for this study includes 10 words associated with positive moods (e.g., "interested; excited; strong") and 10 words associated with negative moods (e.g., "distressed; upset; guilty"), which are rated by respondents providing an estimation of the extent they have felt that way on a 5-points Likert scale like the original version. The adaptation concerns the instructions, which invited the participants to answer thinking of the emotional state they experienced "while teaching" ("pre" condition) and "during the teaching activities, related to the training you attended, that you carried out with the students" ("post" condition). The investigation is not about the emotional state while attending the courses given by the partners involved in the project, but instead about the emotions experienced when applying those principles and teaching methods to class activities with the students. The comparison of the emotions during previous traditional teaching and this GE approach is the object of the current study. The PANAS is used to investigate emotions in teachers' population across various countries, with comparable validity and reliability values (e.g., Albuquerque et al., 2012; Buyukgoze-Kavas et al., 2014; Fernández-Berrocal et al., 2017; Li et al., 2017). Internal reliability of the scale in the current study is investigated using Cronbach's alpha (Negative emotions, 0.825 pre, 0.768 post; Positive emotions, 0.616 pre, 0.696 post). The values of negative emotions are consistent with previous studies, we accepted also values lower than.70 recorded for positive emotions relying on previous studies (Taber, 2018).

(3) Teachers' attitudes toward sustainability issues, assessed with the Attitudes Toward Sustainable Development Scale (Biasutti and Frate, 2017). It is a scale comprising 20 items which conceives sustainable development as a multidimensional construct constituted by four factors, and each of them is measured by the level of agreement with 5 items on a 5-points Likert scale. The four factors include environment (e.g., "When people interfere with the environment, they often produce disastrous consequences"), economy (e.g., Government economic policies should increase sustainable production even if it means spending more money"), education (e.g., "Teachers in college should promote future-oriented thinking in addition to historical knowledge") and society (e.g., "Each country can do a lot to keep the peace in the world"). The scale is purposely designed to quantify the effects of educational activities consistent with sustainability principles, and the values on the four factors are expected to be sensitive to the different topics faced during the educational path. The scale is applied to investigate teachers' attitudes in different languages, showing sound validity and reliability values in the translated versions (e.g., Richter-Beuschel and Bögeholz, 2019, 2020; Andić and Curić, 2020; Echegoyen-Sanz and Martín-Ezpeleta, 2021). Internal reliability of the scale in the current study is investigated using Cronbach's alpha (Environment, 0.603 pre, 0.689 post; Economy, 0.759 pre, 0.758 post; Education, 0.756 pre, 0.792 post; Society, 0.658 pre, 0.751 post; Total, 0.844 pre, 0.862 post). The values are consistent with previous studies, we accepted also values lower than.70 according to previous studies (Biasutti and Frezza, 2009).

4) Teachers' attitudes toward migrants, with a scale adapted by Leong (2008) from the Eurobarometer Survey (Thalhammer et al., 2000). This scale includes 6 items measuring the blame toward immigrants, that is the extent to which the respondent attributes immigrants' individual and social misfortunes to themselves. The scale includes different dimensions, such as education, welfare, insecurity, criminality, treatment from the authorities, unemployment (e.g., "In schools where there are too many immigrants, the quality of education suffers"). In our perspective, such a scale offers an effective integration for the previous Attitudes Toward Sustainable Development Scale, assessing the degree of intercultural sustainability (Busch, 2016). This aspect appears to be particularly relevant considering the focus of the project and its training activities on the relationship between Sustainable Development Goals and migration, which is the core issue of the activities carried out by the partners with the teachers attending the courses. The scale is included in the Eurobarometer's studies covering 15 countries, and its reliability and validity are supported by previous studies (Thalhammer et al., 2000; Leong and Ward, 2006). Internal reliability of the

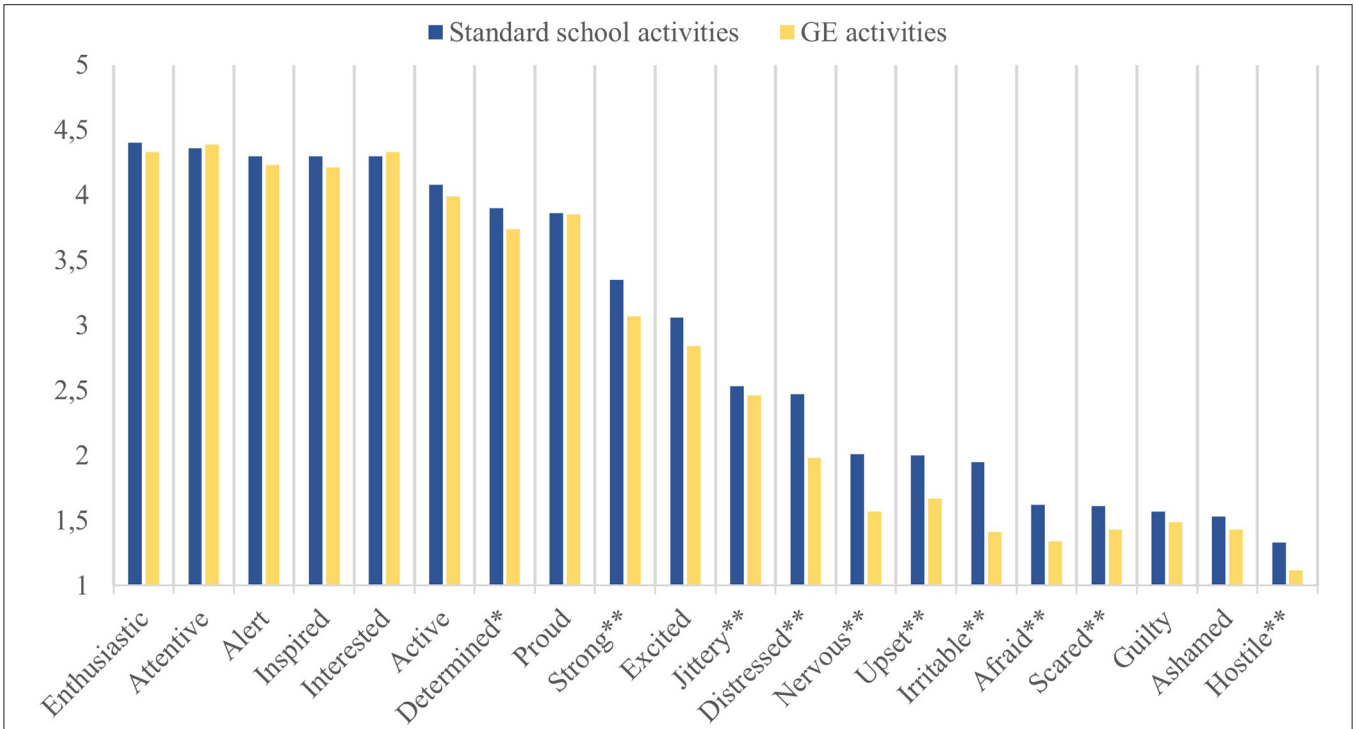

FIGURE 1 | Intensity of teacher's emotions after standard school activities (blue) and Global Education (GE) activities (yellow), PANAS scale by Watson et al. (1988) (average values, $^{*}p < 0.05$, $^{**}p < 0.01$).

scale in the current study is investigated using Cronbach's alpha (0.854 pre, 0.846 post).

All the original instruments were taken from the international literature and were written in English, hence they underwent a translation and back-translation process. The authors supervised the process with local assistants collaborating with the partner NGOs involved in the project, who were all native speakers of the target language, fluent in English and familiar with the principles of GE. For each country a first person provided the translation into the local language, which was subsequently back-translated to English by an independent translator. The comparison of the original version with the back-translations showed minor discrepancies in all languages, which were discussed by the research team involving the local assistants. Small alterations were included both in the items and the instructions, also considering the concerns regarding the clarity of the requests applied to the actual teaching context. Data were collected in an anonymous and aggregated form for statistical purposes only, in compliance with the Declaration of Helsinki and current ethical guidelines for social research provided by the Italian Psychology Association (Associazione Italiana di Psicologia). Analyses were carried out using SPSS statistical software (IBM, version 22).

RESULTS

To test the emotional impact of GE activities (HP 1 and HP2), a comparison was developed between the emotional state declared by teachers during standard school activities and what they experienced working with the students in the context of the GE, aimed at identifying the expected differences due to the new teaching framework. This analysis was performed through an Analysis of Variance (ANOVA).

TABLE 1 | Intensity of teacher's negative emotions after standard school activities and Global Education (GE) activities (average values, $^{**}p < 0.01$).

	Standard school activities (m.)	GE Activities (m.)	Variation (%)
Irritable**	1,95	1,41	−27,69
Nervous**	2,01	1,57	−21,89
Distressed**	2,47	1,98	−19,84
Afraid**	1,62	1,34	−17,28
Upset**	2	1,67	−16,50
Hostile**	1,33	1,12	−15,79
Scared**	1,61	1,43	−11,18
Ashamed	1,53	1,43	−6,54
Guilty	1,57	1,49	−5,10
Jittery**	2,53	2,46	−2,77

As regard to the negative emotions (HP 1), a significant reduction ($p<0.01$) for many of the negative affects (hostility, irritability, distress, upset, scaredness, nervousness, feeling jittery

and afraid) after GE lessons was observed when compared with standard lessons (**Figure 1**). In details, results showed a more intense (above 10%, **Table 1**) decrease in irritability (−27,69 %), nervousness (−21,89%), distress (−19,84%), being afraid (−17,28%), and upset (−16,50 %), hostility (−15,79 %) and scaredness (−11,18 %). Less intense decreases for feeling jittery (−2,77%), ashamed (−6,54%) and guilty (−5,10 %) were detected, the latter two not reaching statistical significance.

Addressing the positive emotions (HP 2), significant variations have been observed only for strength ($p < 0.01$, −8,36%) and determination ($p < 0.05$, −4,1 %), which were higher when referred to standard lessons. Possible age and gender effects on the emotional state of the teachers were also analyzed, to highlight any variations comparing standard school activities and GE activities. Regarding age, correlations (**Table 2**) showed a substantial reduction in emotional intensity (both positive and negative, R= −0.124 and −0.85 respectively, $p < 0.01$) linked to traditional school activities as teachers get older. The same relationship was found not significant when assessing the GE activities (R = −0.37 and −0.12), suggesting that older and more experienced teachers aligned themselves with their younger colleagues in mobilizing their emotional dimension according to the pattern described above. About gender, a significant difference ($p < 0.01$) between men and women in positive emotions associated with traditional school activities (higher intensity in the female gender, **Table 3**) was found. This same difference was not detected in GE activities, as the two genders presented the same emotional pattern. It was not possible to proceed with the statistical analysis of the data of those who identified themselves as not binary due to a limited number of cases. Concerning sustainable attitudes (HP 3), data showed an upward trend in teachers' scores after the GE program on all four dimensions. More in details (**Table 4**), in the pre-post comparison, the average score increased from 3.93 to 4.10 on the environmental dimension of sustainability (+4,33%), from 4.38 to 4.49 on the economic one (+2,51 %), from 3.86 to 3.90 on the social dimension (+1,04 %) and from 4.49 to 4.55 on the educational one (+1,34 %). However, this trend reached statistical significance ($p < 0.01$) for two dimensions only:

TABLE 2 | Correlations between teachers age and the intensity of their positive/negative emotions after standard school activities and Global Education (GE) activities (R, $^{**}p < 0.01$).

	Standard school activities		GE activities	
	Positive emotions	**Negative emotions**	**Positive Emotions**	**Negative emotions**
Teachers' age	−0.124**	−0.85**	−0.37	−0.12

TABLE 3 | Correlations between teachers' genders and the intensity of their positive/negative emotions after standard school activities and Global Education (GE) activities (average values, $^{**}p < 0.01$).

	Positive Emotions		Negative Emotions	
	Standard school activities**	**GE activities**	**Standard school activities**	**GE activities**
Men	3,28	3,15	1,68	1,41
Women	3,52	3,28	1,73	1,41

TABLE 4 | Intensity of teacher's attitudes toward sustainability before and after their Global Education (GE) activities (average values, $^{**}p < 0.01$).

	Before GE activities	**After GE activities**	**Variation (%)**
Environmental**	3,93	4,1	4,33
Economic**	4,38	4,49	2,51
Educational	4,49	4,55	1,34
Social	3,86	3,9	1,04

TABLE 5 | Correlations between teachers' age and their scores on the attitudes toward sustainable development scale before and after their Global Education (GE) activities (R, $^{**}p < 0.01$).

	Environment		Economy		Society		Education	
	Before GE activities	**After GE activities**	**Before GE actiities****	**After GE actiities****	**Before GE actiities****	**After GE activities**	**Before GE activities**	**After GE activities**
Teachers' age	−0.12	0.15	−0.95	0.90	0.71	−0.34	−0.50	−0.30

TABLE 6 | Teachers' gender and their scores on the attitudes toward sustainable development scale before and after their Global Education (GE) activities (average values, $^{**}p < 0.01$).

	Environment		Economy		Society		Education	
	Before GE activities	**After GE activities**	**Before GE activities**	**After GE activities****	**Before GE activities**	**After GE activities**	**Before GE activities****	**After GE activities**
Men	3,9	4,13	4,38	4,62	3,84	3,96	4,41	4,54
Women	3,94	4,05	4,38	4,45	3,87	3,9	4,52	4,54

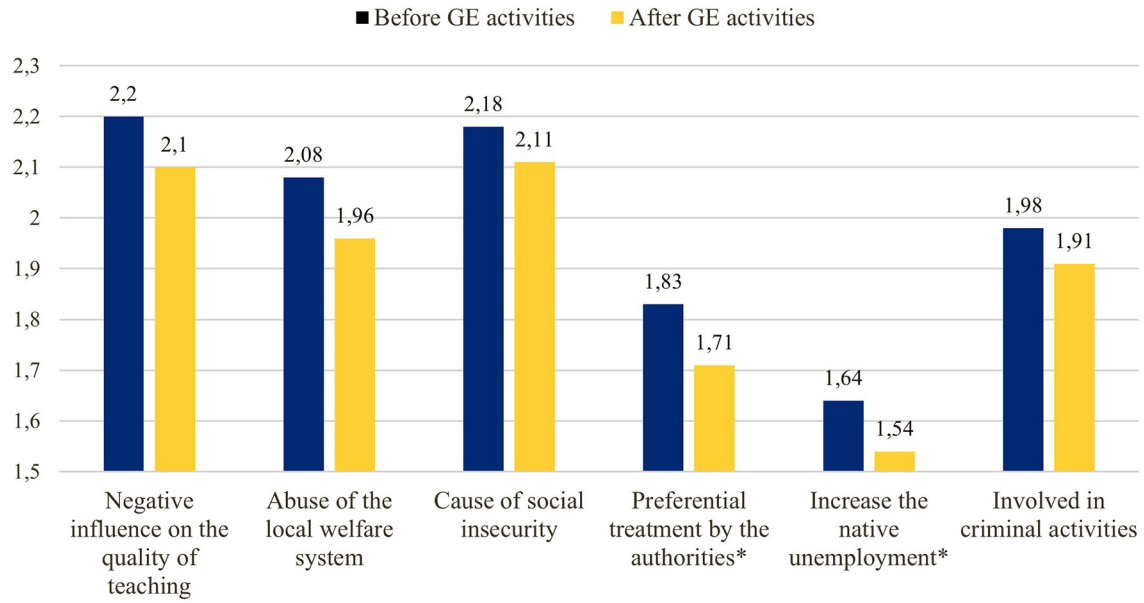

FIGURE 2 | Intensity of teachers' negative attitudes toward migrants before (blue) and after (yellow) Global Education (GE) activities, scale by Leong (2008) (average values, $^{*}p < 0.05$).

environmental and economic. As already observed for emotions, the GE activities had a flattening effect on gender and age. Baseline correlation data showed indeed a significant increase in sustainable attitudes with older age on two sub-factors, namely environmental and economic sustainability (**Table 5**). Conversely, analyzing the data collected at the end of the GE activities no further differences related to the teachers' age were detected. Furthermore, **Table 6** shows that not only the average dispositions toward sustainability increased in both genders in the pre-post comparison, but also that the difference previously detected ($p<0.01$) on the dimension of educational sustainability disappeared, whereas a variation on the economy factor emerged.

Finally, negative attitudes toward migrants were also compared, testing HP 4 (**Figure 2** and **Table 7**). The expected reduction in negative attitudes was found. The general average scoring of the adopted scale showed a significant decrease ($p < 0.5$, from 1.98 to 1.88). Considering the single items, significant changes ($p < 0.5$) on two beliefs were detected ("Migrants have a preferential treatment by the authorities," −6,56 %, and "Migrants contribute to increase unemployment among natives," –6,09 %).

Moreover, a significant correlation ($R = 0.71$; $p < 0.05$) between age and negative attitudes toward migrants was found analyzing the baseline data, as prejudices toward them increased as teachers get older. Conversely, no differences due to age were detected after the GE activities, highlighting that older teachers were subject to the same decreasing trend noticed above. No significant variations by gender were observed.

TABLE 7 | Intensity of teachers' negative attitudes toward migrants before and after their Global Education (GE) activities (average values, $^{**}p < 0.01$).

	Before GE activities	After GE activities	Variation (%)
Negative influence on quality of teaching	2,22	2,10	−5,41
Abuse of the local welfare system	2,08	1,96	−5,77
Cause of social insecurity	2,18	2,11	−3,21
Preferential treatment by the authorities**	1,83	1,71	−6,56
Increase the native unemployment**	1,64	1,54	−6,09
Involved in criminal activities	1,98	1,91	−3,54

DISCUSSION

Results showed that the applied GE activities had significant positive effects on all the addressed variables: emotions associated with teaching, attitudes about sustainability, understood as a multidimensional concept, and the mitigation of negative attitudes toward migrants.

As regard to HP 1, it was found to be fully verified as significant decreases compared to standard school activities were observed for a wide range of negative emotions. It implies that GE activities have had a general impact in reducing the usual teaching

stress, and an even stronger influence on more momentary and context-dependent emotions (e.g., irritability, nervousness). These findings present wider implications, as psychological stress and burnout in teachers are a social problem that impacts on their personal health, on the quality of their job performances and on students' education (i.e., Klusmann et al., 2008; Saloviita and Pakarinen, 2021). Also, as pointed out by Herman et al. (2020), most teachers present a latent profile characterized by a high stress coupled with high (66%) or low (28%) coping skills, whereas only 6% of them experience low stress levels at work. It can therefore be argued that spreading GE-based activities at school would have a significant impact on the balance between stress levels and coping skills, decreasing the extent of perceived stress, and positively affecting the actual incidence of burnout and mental health problems. Moreover, according to Koenen et al. (2019), the presence of less intense negative emotions can be related to a greater sensitivity toward students, as well as fostering higher levels of engagement during classroom activities (Burić and Macuka, 2018). More in general, a decrease in teachers' negative emotions constitutes a positive factor for their educational performances, as negative emotions have been often found to be related with diminished levels of cognitive functioning and motivation while teaching (Sutton and Wheatley, 2003). Concerning age, a substantial leveling effect for GE activities was detected. This allows us to infer that the emotional differences related to individual experience (i.e., years of teaching), characterizing standard classroom activities, are not present for GE activities. These latter activities could therefore be a factor in promoting a more egalitarian psychological experience, at least as regards negative emotions, favoring fruitful forms of intergenerational dialogue between teachers.

Although GE activities have had a significant impact reducing negative emotions linked to teaching, the same cannot be said for positive ones, which remained stable in most cases. The HP 2 is therefore not confirmed. This result is not entirely surprising if it is considered that teachers declared experiencing a high average level of positive emotions associated with standard school activities too, and that many of the measured affects evoked a high mobilization of psychophysical abilities for performance purposes, such as alertness, determination, and strongness.

Considering the results on emotional states, it can be concluded that GE activities show a significant decrease in the intensity of negative affects without any impact on most of the positive affects, which maintain the high intensity experienced by teachers linked to standard school activities. It must be further investigated if this is a prerequisite for promoting optimal experiences among teachers, as the resulting emotional pattern emerged after GE activities is consistent with a better balance between environmental challenges and perceived skills which is one of the features of flow experience.

Addressing HP 3, results proved its consistency, as an upward trend in attitudes toward sustainability was found after GE activities in comparison with the baseline data. Remarkably, this trend is established despite the high baseline values of teachers' attitudes, attesting that GE activities can promote further development of sustainable consciousness even where it is already well-developed. Those findings also highlighted that school activities based on the GE framework can significantly impact on sustainable attitudes as previously demonstrated for similar educational approaches with teachers, namely Education for Sustainability (Merritt et al., 2019) or Education for Sustainable Development (Andersson et al., 2013; Nousheen et al., 2020; Braßler and Sprenger, 2021). As higher sustainable attitudes have been generally found to reinforce the subjective pro-environmental behaviors (Gifford and Sussman, 2012) and, in the case of teachers, affect in turn their students' values (Murphy et al., 2020), it can be argued that participating in GE activities could have positive effects on the sustainable behavior of the teachers themselves and on their students' sustainable awareness. Data also suggested that the pre-post difference was significant only on two subscales: environmental and economic sustainability. This may have been due to the thematic focus of the project on inequalities and their environmental effects, but the multiplicity of the applied activities does not allow a linear verification of this hypothesis, which should be tested in future research. Regarding age, results suggested a stronger focus of older teachers on economic sustainability after GE activities, as well as a leveling effect on the social one. As for gender, GE activities exerted a major focus on economic sustainability was detected in males after GE activities, whereas this latter showed an equalizing effect on the importance that men and women teachers attributed to educational sustainability.

Concerning HP4, it was fully verified, as a significant decrease of negative attitudes toward immigrants within teachers was observed after GE activities, in comparison with the baseline. As also noted above, this result occurs even though the average level of prejudice in teachers was already low at the beginning. Participation in GE-based activities was therefore found to be effective in reducing negative attitudes toward migrants in a target, such as that of teachers, who already had a strong awareness on this topic. More generally, as to fight against the explicit and implicit forms of racism and discrimination at school is a crucial issue in today's multicultural societies (Farkas and Gergely, 2020) our results could support the extensive use of GE-based training programs for teachers, as their efficacy on promoting a decreasing in prejudice was tested.

CONCLUSIONS

The findings of the current article offer a strong support for the application of GE principles, yet they are subject to some limitations. In the first place there is no control group as the project did not provide the chance of collecting data from a homogenous population not involved in GE activities for the sake of comparison. This offers the possibility of reasoning about correlations between the selected variables, but without knowing if the observed effects are due specifically to the GE principles or other experimental conditions. The results might be attributable also to the well know Hawthorne effect in this case study, as the effort put by the employer school in offering training activities, the involvement of external actors (e.g., NGOs) and the direct connection with applied activities are relevant factors that may influence the experience of the

teachers. This limitation is shared with many studies on the impact of similar approaches (Nousheen et al., 2020; Braßler and Sprenger, 2021), as the many intervening variables (e.g., organizational, didactic, and social) generally hinder the use of control groups in the school environment. Strengthening the collaboration between school institutions in charge of the didactic and organizational activities and actors carrying out assessment and analysis would offer a better comprehension of alternative educational approaches. Moreover, desirability biases and compliance with the observers may have influenced teachers answers, especially considering the sensitive issues at stake; despite this, we argue that a partial reduction of such effect was achieved by using self-administered surveys instead of interviews and guaranteeing the anonymity of respondents by not providing schools (or local project representatives) with direct feedback on their teachers' responses. One of the most relevant improvement of the current study implies a further investigation including teachers maintaining the traditional activities with students, as it would offer the opportunity for a direct comparative assessment which can lead to a better appraisal of GE approach effects. In the second place, teachers' emotional states were measured at the end of the teaching period, through deliberate answers to questions investigating the memory of the overall experience which lasted several months. The necessary mental elaboration for such a request can increase the distance between the momentary emotional state and its recollection. Applying a research procedure like the Experience Sampling Method (ESM), which collects systematic answers at random times during the daily lives of participants (Larson and Csikszentmihalyi, 2014), is a fruitful integration to the approach developed in the current study. Moreover, the opportunities offered by wearable digital devices can extend the analysis to psychophysiological measures, providing real-time, not voluntarily controlled, and non-invasive assessment of teachers' personal experience. Combining such information is considered a more complete representation of subconscious and conscious emotions (Chamberlain and Broderick, 2007). In the third place, the large sample size included a heterogeneous population which varied according to a range of variables; despite all the activities were designed by the partners under the coordination of the project leader and inspired by common GE principles, local differences affected the actual implementation of the activities (e.g., locally relevant topics, activities' locations, peculiar ways in which the GE methodology has been integrated into the subject of teaching). Observations conducted in a more homogenous sample can facilitate controlling for such variables. Finally, national differences have not been addressed in this article, but it is reasonable that they may represent an element of variability among teachers when emotional dimensions and sustainable attitudes are concerned. Therefore, future research would investigate the cultural differences between teachers on a European or international scale and how these could impact on the effectiveness of GE programs, possibly reducing other intervening variables.

Notwithstanding such limitations, these results suggest some reflections on GE approach and its assessment. In general, the data provide sound support to the transformative potential of GE for teachers, as the affective state is positively influenced by the training and the actual implementation of such principles in daily teaching practice. These also positively modify different dimensions of sustainability, namely environmental, economic and intercultural. Although a significant change is not observed for all the assessed sustainability dimensions, results are consistent with the declared GE principles and the wider SDGs framework which encourage a holistic approach. Moreover, although teachers of different age and gender experience diverse emotional reactions after traditional teaching activities, GE activities are associated with more homogenous emotional patterns across the different socio-demographic populations. This implies that GE approach can be conceived as a fruitful protective factor against work-related stress for teachers, not only because it diminishes negative emotions, but also thanks to its capability of inducing a more uniform affective state in teachers' population. Having a more positive emotional experience while teaching and perceiving it as a common state shared with colleagues can foster teachers' wellbeing.

The relevance of these results is twofold, as they offer new insights both on the theoretical and practical level. Theoretically they fill the gap about the psychological impact of GE on teachers, thus completing the framework offered by previous research about teachers' needs emerging from traditional approach to teaching (Mundy and Manion, 2008; Reysen and Katzarska-Miller, 2018) and motivations supporting the adoption of GE principles (Biberman-Shalev, 2021). Practically, it suggests that fruitful constructs can be identified from the literature, whose selection should be partly based on the specific contents of the teaching courses and the objectives of the assessment for all the actors involved. In general, notwithstanding the possible differences resulting from the theoretical and methodological choices made, we consider the psychological assessment approach as a fruitful integration in this kind of teaching initiatives to provide insights about their impact. Such type of assessment allows scholars and professionals to go beyond the mere description of a phenomenon, for example recording the satisfaction for a specific course; it opens the way for making hypotheses on the mental mechanisms underlying the efficacy of a teaching approach, strongly connecting the results with the literature on the selected constructs.

Yet, when it comes to defining some guidelines for implementing GE initiatives, the issue of measurement must not be conceived only as an assessment tool, emphasizing the usage of data for an estimation of the performance of a training activity. Certainly, it can be a useful support for comparing different approaches, methodologies, school subjects, and for providing sound quantitative support to other qualitative inquiries. However, in addition to this knowledge about performance it can be a powerful tool for self-reflection of teachers, providing detailed feedback on the results attained as a personal and professional growth in line with the opportunities offered by ESM method. This can inform the individuals and the institutional actors involved in the process and in charge of making decisions about the design and implementation of new teaching initiatives. The ultimate goal is to make them more aware of the importance of integrating assessment tools as a

fundamental element of the design phase, broadening the field of observation including not only the technical competences acquired but also the personal transformation taking place and its perceived quality. Indeed, such psychological change can account for a long-lasting transformation of teachers and their behavior. Such approach would offer policy makers and school professionals (e.g., teachers and principals) theoretical and practical tools to be better equipped with evidence-based findings to face the challenges of education in a global age (Ramkissoon, 2022). The conception of education both as a "subject and object" of change (Marginson, 1999, p. 20) assigned a greater responsibility to teachers in developing a sense of citizenship by means of curricula and pedagogical choices (Vongalis-Macrow, 2004). These local education policies interact with the national level, which in turn deals with a global agenda for education (Edwards, 2017): the resulting field includes both international actors (e.g., multilateral institutions, foreign aid agencies, international NGOs, transnational corporations, consultancy companies, and philanthropic foundations) and national actors (e.g., policymakers, governmental agencies, national NGOs) (Ball, 2012; Lingard et al., 2015). This complex scenario involves different approaches to education policies and calls teachers to find a balance between global and local interests. Conceiving psychological assessment as both a performance and self-reflection tool can supply teachers with a reference to deal with such complexity, supporting them in comparing heterogenous educational contexts and in developing effective coping mechanisms in the long term (Ramkissoon, 2021).

The results must be conceived as a platform for developing future research on the GE approach to teaching. In addition to the further research suggested to overcome the limitations of the current study, other directions of investigation can be considered. A direct comparison between GE and other approaches suggested by the literature would be beneficial, to identify the most fruitful theoretical frameworks to strengthen the impact of education in reaching SDGs. Moreover, a closer classification of enacted educational practices (e.g., educational tools, length of the program activities, actors involved in addition to school teachers, subjects taught) could shed light on how effective the integration of GE principles is in daily school activities. The psychological variables should also be complemented by behavioral variables, regarding for example school activities (e.g., the availability to take responsibility for other school duties of tutorial nature, or to engage into multidisciplinary projects) and other non-strictly educational tasks (e.g., involvement in civic duties). This would help in understanding the impact of the psychological variables on the actual behavior, focusing on the specific population of teachers. These types of observation should also be extended to students, offering empirical support to the final impact of GE on young generations and the actual transfer of the positive effects observed among teachers to the wider population of students.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because of the agreements among the partners involved in the project. Requests to access the datasets should be directed to marco.boffi@unimi.it.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MB: conceptualization, methodology, investigation, data curation, and writing–review and editing. NR: conceptualization, methodology, formal analysis, investigation, data curation, and writing–original draft. PI: supervision. All authors contributed to the article and approved the submitted version.

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Environmental threat in France: Two studies testing the effect of threatening messages on system justification and environmental denial

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Climate change consequences are affecting our entire political, economic and social system. At a psychological level, it represents a large number of threatening events that we have to deal with. In the scientific literature, there is an active debate about the inconsistent effects of environmental threatening messages. One explanation for this inconsistency is that people respond differently to a threat, depending on some psychological dispositions. Indeed, studies on system justification theory showed that when people with a right political orientation are exposed to a threat to their system, they show a motivation to defend it. Although those tendencies have been linked to environmental denial, there is a lack of experimental studies testing the direct effect of environmental threat, especially in European context. We address this issue with two experiments in which we highlighted the environmental threat for one's system (Study 1, $N = 144$) and for the continuity of one's habits (Study 2, $N = 148$) in a French sample. The design was the same for both studies: three types of video-clips were presented to participants (i.e., control, neutral and threat) and we measured general system justification, environmental denial and political orientation. Our results showed no significant effect of our threat manipulation in both studies. However, they support that a right political orientation in France positively predicts system justification tendencies in study 1 and environmental denial in study 2. Findings are discussed through theoretical and methodological implications.

KEYWORDS

environmental threat, system justification, environmental denial, political orientation, system threat

Introduction

Climate change consequences are affecting not only our physical environment but also our psychological and social environment. Accordingly, it represents a multi-level threat that we have to deal with. Even though the main consequences are now irreversible (Intergovernmental Panel on Climate Change [IPCC] et al., 2021), we can still limit the severity of some disasters. To address this challenge, psychologists can help to improve the understanding of psychological and contextual barriers that undermine

environmental actions (e.g., Gifford, 2011; Swim et al., 2011; Hornsey and Fielding, 2020). In this research, we will focus on the obstacle resulting from the tendency to justify one's system and to deny environmental problems in the context of environmental threat. More specifically, we address the hypothesis proposed by Feygina et al. (2010) about the effect of the environmental threat on system justification tendencies and denial, depending on political orientation.

Environmental threat

When authors used the expression "environmental threat" in the literature, it implicitly refers to all the negative physical, social and psychological impacts of climate change (Reser et al., 2011). The set of negative consequences referred to, in the literature, includes a large variety of phenomena that are more or less severe, more or less likely and more or less controllable. For a better understanding of its effects at the psychological level, we must first establish the perimeter of what is considered a threat. In this article, we follow the distinction by Crawford (2017) on "meaning threats" and "physical threats." He defines physical threat as a physical danger that poses a risk to people's safety (i.e., potential death) and meaning threat as an event that violates "one's senses of belonging, identity, purpose, significance, continuity, or certainty" (Crawford, 2017, p. 356). Due to the numerous consequences of climate change, researchers can induce environmental threat with both types depending on their objectives. In this research, we chose to study the "general meaning threat" posed by climate change because most people in Europe have not experienced severe climate danger as described by "physical threat." Moreover, even the meaning threat can refer to different types of threat. In this research, we decided to distinguish two levels of this general meaning threat: one concerning the political, economic and social system and the other directly concerning the continuity of individual life habits.

If most European countries are, for now, relatively spared by climate change consequences, the experience of the environmental crisis is mostly indirect through social media, newspapers or technologies (Reser et al., 2011). It is therefore common for researchers to use these same communication methods as materials to recall the threatening aspects of climate change. More specifically, inducing a sense of threat often consists of exposing people to pessimistic messages about the severity of climate change consequences. However, this type of operationalization has led to inconsistent outcomes (e.g., van Zomeren et al., 2010). On the one hand, some studies found that the perceived threat of climate change can be positively associated with personal efficacy (Byrne and Hart, 2009; Hornsey et al., 2015). Moreover, results have shown that when people are threatened by dire messages, they increase their intentions to reduce energy consumption (Hartmann et al., 2014) and engage in more pro-environmental behaviors (Kim et al., 2013). On the other hand, researchers have also found that dire messages can encourage people to deny the problem and ignore it (Feinberg and Willer, 2011; Hart and Feldman, 2014). Moreover, some studies failed to find an increase of pro-environmental intentions and behaviors (O'Neill and Nicholson-Cole, 2009; Weinstein et al., 2015). To explain these inconsistent findings, some authors found that dispositional factors, such as political orientation, may moderate individual response to threatening communication (e.g., Häkkinen and Akrami, 2014; Hoffarth and Hodson, 2016; Clarke et al., 2019). This literature is consistent with the hypothesis that, in the face of threatening climate events, people would engage in defensive cognitive processes and minimize climate change severity. It is from this perspective that this research is conducted. Among the many processes and dispositional factors that have been identified as barriers to attitudinal and behavioral changes, we focus here on system justification tendencies and political orientation (e.g., Gifford, 2011; Hornsey and Fielding, 2020).

System justification

System Justification Theory suggests that people are motivated to enhance the legitimacy of their own system (Jost et al., 2004). A large body of research demonstrated that system justification is especially prevalent in threatening contexts and for right political ideologies (e.g., Kay and Friesen, 2011; Friesen et al., 2019; Jost, 2019). According to Jost et al. (2010), the tendency to justify one's system is enhanced when the system is threatened or criticized. Although this effect has been shown for different types of threats (for a review, see Kay and Friesen, 2011), this claim has not yet been tested for environmental threat. According to Feygina et al. (2010), climate change can be considered as a threat to the system because acknowledging the role of human activity would imply challenging the foundations of our social, political and economic system. Indeed, climate change represents, *per se*, a threat to the significance of the current system and to the continuity of individuals' habits. It has been proposed that system justification tendencies and environmental denial can be increased by environmental threat, specifically for right political orientation but, to our knowledge, there are only few studies that investigate this issue (e.g., Clarke et al., 2019). Testing this effect is the first objective of this research.

In the United States political system there is strong evidence that right political orientation and conservatism are positively associated with system justification tendencies (Jost, 2019) and environmental denial (e.g., McCright and Dunlap, 2011). Several studies also demonstrated that perceived threat, system justification tendencies and right political orientation are relevant factors to understand environmental

attitudes (e.g., Feygina et al., 2010; Jylhä and Akrami, 2015; Clarke et al., 2019). Moreover, a recent meta-analysis showed that political orientation and voting behavior are strong predictors of environmental denial while controlling for other sociodemographic factors (Hornsey et al., 2016). It is therefore relevant to explore the role of system justification and political orientation when studying the effect of the "meaning threat" posed by climate change. However, most studies are based on the American political system. To our knowledge, there are no studies addressing the specific link between environmental denial, system justification and political orientation in the French context and that is the second objective of this research.

French political context

Although Jylhä and Akrami (2015) have shown that right political orientation in European context is associated with environmental denial and system justification, it is not clear how to draw a parallel with the French political system. In France, nearly a quarter of the population still doubts that global warming is occurring (Opinion Way Pour PrimesEnergie, 2019). Moreover, based on a recent national survey, Teinturier et al. (2019) showed that right political orientation (i.e., affiliation to "Rassemblement National" and "Les Républicains") is descriptively associated with less concern for environmental issues. Similarly, Vasilopoulos and Lachat (2018) showed that right political orientation in France is positively associated with the concept of authoritarianism, which is also associated with system justification tendencies (Friesen et al., 2019). Taking into account these results, we hypothesized that the links established in the United States would be, in some way, similar in the French political system.

Present research

With two studies, we address three main hypotheses. The first one is that when people are exposed to a threatening message that highlights the negative impacts of climate change for the French system, they will have a greater tendency to justify it and deny environmental problems (Study 1). The second hypothesis is that when people are exposed to a threatening message that highlights the growing pressure to change one's habits, it would encourage them to deny environmental problems (Study 2). In both studies, we also expected that right political orientation will be associated with system justification tendencies and environmental denial. Data collection was undertaken between March and May 2019, before the COVID-19 pandemic. Data, materials and codes are available on the OSF repository.[1] Both sample sizes were determined by time and resources constraints; we could only collect data from 150 students for each study. We justify the degree to which these samples are informative with sensitivity analyses. Also, incomplete data were not included in the final samples.

Study 1

In the first study, we investigated how highlighting the threatening impacts of climate change for the French system could increase system justification tendencies and environmental denial while taking into account political orientation. To do so, we exposed undergraduate students to three types of video-clips (control vs. neutral vs. system threat) and we measured general system justification, environmental denial and political orientation. We expected that participants in system threat condition will have a greater score of system justification and environmental denial than those in control and neutral conditions. We also expected that a right political orientation will be positively associated with system justification and environmental denial.

Method

Participants

One hundred and forty-eight undergraduate students in social sciences (114 females, 34 males, M_{age} = 20.45, SD_{age} = 2.54) were recruited on the campus in exchange for course credits. A power sensitivity analysis indicates that with this sample size, we would have been able to detect a minimal effect size (η^2) of 0.077, given $\alpha = 0.05$ and power $(1-\beta) = 0.80$.

Materials and procedure

The study was conducted at the university campus laboratory and was presented as a study on digital media communication methods. After signing the informed consent, the experimenter gave the instructions to the participant. At the end, all participants were debriefed.

To induce the environmental threat, three types of 1 min and 43 s video-clip were created (control vs. neutral vs. system threat). Videos of natural and human-made landscape videos were used, accompanied by a short text for the neutral vs. system threat conditions. A third control condition was necessary to avoid a possible effect of natural images presentation. Thus, in the control condition, participants were asked to watch the video with no text. In the neutral condition, participants watched the same video with a text about the force of gravity. In the system threat condition, the text highlighted threatening aspects of climate change, for example it contained sentences like "the French system will have to be completely restructured around climate change issues" and "France has a lot to learn and will soon be forced to change its system, its laws and its organization" (the complete texts

1 https://osf.io/9k86r/

are available on the Open Science Framework depository: see text footnote 1).

Environmental denial was measured with the 16 items (ω = 0.76) from Häkkinen and Akrami (2014) and general system justification was measured with the 8 items (ω = 0.84) from Kay and Jost (2003). Both scales were translated with a double-blinded approach. For political orientation, we asked participants to place themselves on a continuum from 1 (Extreme left orientation) to 9 (Extreme right orientation). Participants were mostly left-oriented (M = 3.97, SD = 1.28) and had rather low scores on system justification (M = 3.69, SD = 1.10) and on environmental denial (M = 2.27, SD = 0.78). All correlations are reported in **Table 1**.

Results

We analyzed our data with two multiple regression models with planned contrast codes for the type of video-clips, as recommended by Brauer and McClelland (2005). The first model tested the effect of the type of video-clips on system justification score while controlling for the interaction with political orientation. The second model tested the effect of the type of video-clips on the environmental denial score while controlling for the interaction with political orientation and also controlling for the system justification score. For each model, we tested both the main contrast code C1 (control = −1, neutral = −1, threat = + 2) and the residual contrast code C2 (control = −1, neutral = + 1, threat = 0).

The result for the first model indicated that there was no significant difference between the type of video-clips for C1, b = −0.19, 95% CI [−0.56, 0.19], $t(142)$ = −0.97, p = 0.34, nor for C2, b = −0.07, 95% CI [−0.80, 0.67], $t(142)$ = −0.18, p = 0.86. Thus, there was not enough evidence to suggest that system justification score was different between the control condition (M = 3.82, SD = 1.03) and neutral condition (M = 3.79, SD = 1.14) vs. the system threat condition (M = 3.50, SD = 1.14) (see **Figure 1**). However, the model confirmed that political orientation strongly and positively predicted system justification, b = 0.28, 95% CI [0.14, 0.41], $t(142)$ = 4.04, $p < 0.001$, $\eta_p^2 = 0.108$. It means that the more people were right oriented, the more they justified their system. Although, political orientation did not appear to interact with the effect of threat on system justification, b = 0.03, 95% CI [−0.06, 0.12], $t(142)$ = 0.61, p = 0.54, for the main contrast.

The result for the second model indicated that the type of video-clips did not reach the significance level for both C1, b = 0.04, 95% CI [−0.23, 0.31], $t(141)$ = 0.28, p = 0.78, and C2, b = 0.03, 95% CI [−0.50, 0.55], $t(141)$ = 0.11, p = 0.91. Thus, there was not enough evidence to suggest that environmental denial score was different between the control condition (M = 2.20, SD = 0.77) and neutral condition (M = 2.48, SD = 0.84) vs. system threat condition (M = 2.17, SD = 0.73). As expected, system justification positively predicted environmental denial, b = 0.18, 95% CI [0.03, 0.27], $t(141)$ = 2.49, p = 0.035, η_p^2 = 0.042, it means that higher system justification tendencies were associated with higher environmental denial score. Moreover, political orientation did not reach the significance level (although "marginally"), b = 0.10, 95% CI [−0.00, 0.20], $t(141)$ = 1.97, p = 0.051, η_p^2 = 0.027, and, as the previous model, did not interact the effect of threat on environmental denial, b = −0.02, 95% CI [−0.08, 0.05], $t(141)$ = −0.53, p = 0.60, for C1.

TABLE 1 Intercorrelations for variables by study.

Variables	1	2	3
Political orientation	—	0.34***	0.24**
System justification	0.23**	—	0.27**
Environmental denial	0.24**	0.19	—

Correlations for study 1 (n = 148) are shown above the diagonal. Correlations for study 2 (n = 144) are shown below the diagonal. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Study 2

In the second study, we investigated how highlighting threatening aspects of climate change for individuals could increase environmental denial while taking into account the interaction with political orientation and also controlling for system justification tendencies. As study 1, we exposed undergraduate students to three types of video-clips (control vs. neutral vs. individual threat) and we measured system justification, environmental denial and political orientation. We expected that participants in threat condition will have a greater score of environmental denial than those in control and neutral conditions. We also expected that a right political orientation will positively predict environmental denial, controlling for system justification.

Method

Participants

One hundred and forty-four undergraduate students in social sciences (111 females, 33 males, M_{age} = 20.65, SD_{age} = 2.50) were recruited on the university campus in exchange for course credits. With this sample size, we would have been able to detect a minimal effect size (η^2) of 0.079, given α = 0.05 and power (1–β) = 0.80.

Materials and procedure

We used the same methodology as in study 1, participants were exposed to the same video-clips, except for the text accompanying the threat condition. In this study, we

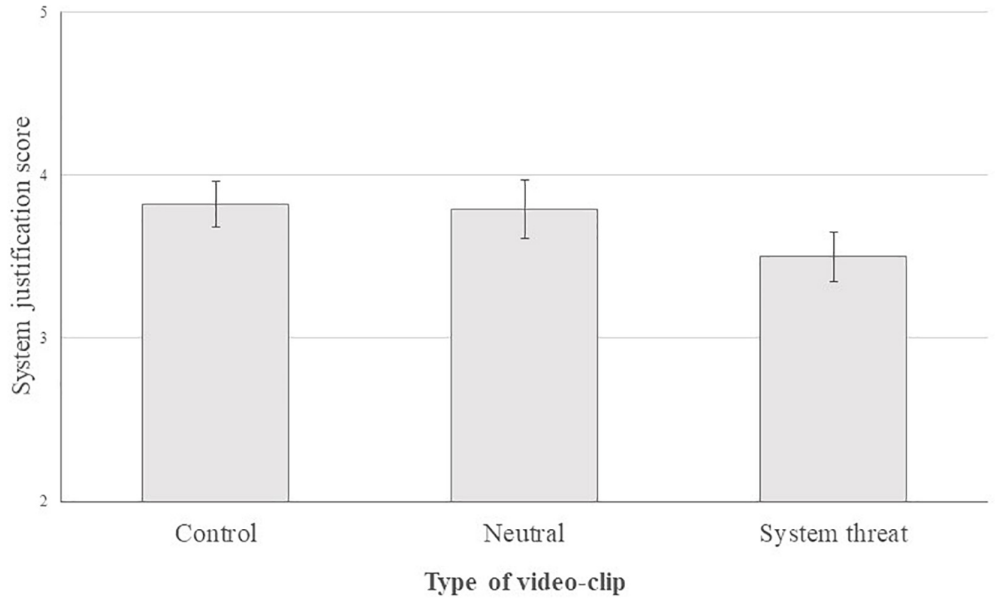

FIGURE 1
System justification score depending on video-clip type. Errors bars indicate the standard error.

highlighted the necessity for individuals to change their way of life with sentences like "you will have to adopt a number of daily restrictions and eliminate your inappropriate behavior" or "You have a lot to learn and will soon be forced to change your habits and lifestyle" (the complete texts are available on the Open Science Framework depository: see text footnote 1).

Measures and scores were exactly the same as with study 1. Like the sample in study 1, participants were mostly left-oriented (M = 4.14, SD = 1.54) and had rather low scores for system justification (M = 3.60, SD = 1.09, ω = 0.76) and for environmental denial (M = 2.62, SD = 1.02, ω = 0.86). All correlations are reported in **Table 1**.

Results

We conducted a multiple regression model with the same planned contrast codes used in study 1. We controlled for system justification and for the interaction between our conditions and political orientation.

For the type of video-clips, results did not reach the significance level for both the main contrast, b = −0.06, 95% CI [−0.35, 0.22], $t(137)$ = −0.44, p = 0.659, and the residual contrast, b = 0.24, 95% CI [−0.24, 0.72], $t(137)$ = 0.98, p = 0.330. Thus, the environmental denial score was not significantly higher in threat condition (M = 2.71, SD = 1.11) vs. control condition (M = 2.05, SD = 0.78) and neutral condition (M = 2.50, SD = 0.74) (see **Figure 2**). Moreover, system justification did not reach the significant level to predict environmental denial, b = 0.11, 95% CI [−0.03, 0.24], $t(137)$ = 1.60, p = 0.112, η_p^2 = 0.018. The data also indicated that political orientation positively predicted environmental denial, b = 0.11, 95% CI [0.02, 0.20], $t(137)$ = 2.30, p = 0.023, η_p^2 = 0.037. Thus, the more people declared themselves as right oriented, the more they presented high environmental denial scores. However, political orientation did not moderate the effect of threat on environmental denial, b = 0.05, 95% CI [−0.02, 0.12], $t(137)$ = 1.52, p = 0.132, η_p^2 = 0.016, for the main contrast.

General discussion

Our data did not support the hypotheses for system and individual threat but are consistent with the literature indicating that right political orientation and system justification are relevant factors when studying environmental denial. Thus, in both studies, the induction of environmental threat appears not to be effective. To discuss our failed manipulation, we propose three main explanations. First, our sample is mainly composed of young females, slightly left-oriented. Numerous articles have now demonstrated that system justification and threat responsiveness are stronger for men with a right-wing ideology (e.g., McCright and Dunlap, 2011). It is therefore possible that, because of the characteristics of our sample, we were not able to observe an effect of threat on system justification and environmental denial scores. Second, it is likely that our choice to induce environmental threat with texts in videos was not completely effective. Because we did not control for perceived threat between conditions, we cannot be sure that participants felt more or less threatened between conditions.

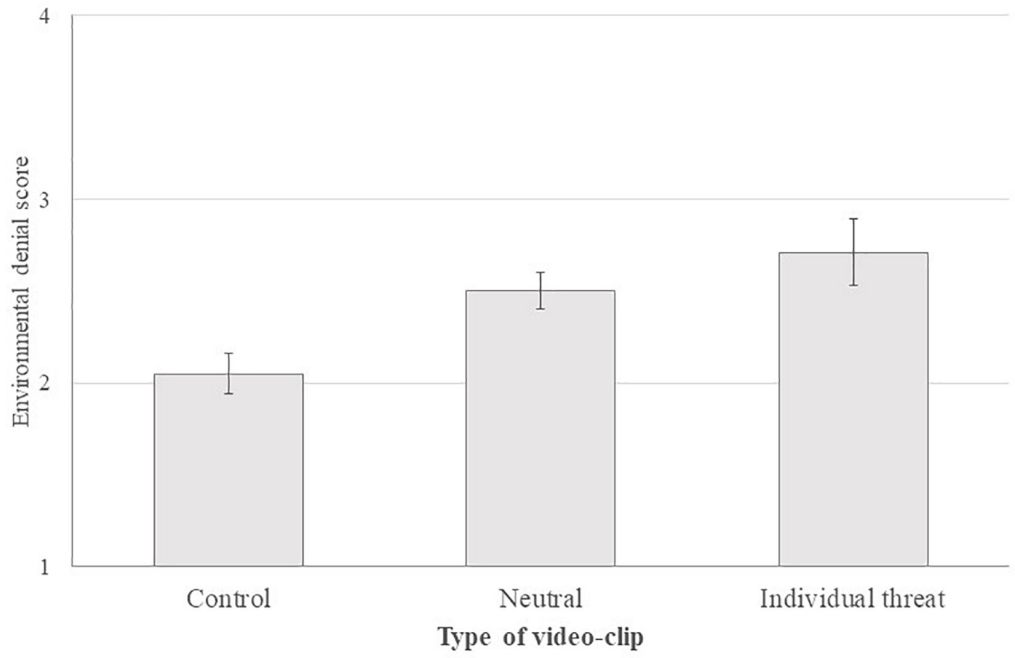

FIGURE 2
Environmental denial score depending on video-clip type. Errors bars indicate the standard error.

A third explanation concerns our conceptualization of the environmental threat. While we distinguished two levels of this general meaning threat (i.e., system vs. individual), we did not focus on one specific consequence of climate change. It means that the content of the threatening messages may not have been specific enough. As a limitation, we are aware that the size of our samples may not have allowed us to detect the effect, if indeed it exists.

Moreover, the debate about the inconsistent effects of threatening messages on environmental attitudes is ongoing (e.g., Voelkel et al., 2021). While we find no evidence here to support the hypothesis that political orientation can moderate the effects of environmental threat, as proposed by Feygina et al. (2010), we contribute to this debate with additional data. Because "environmental threat" is composed of a wide range of threatening events, the definition of this threat and of political orientation may influence future hypotheses, specifically when researches are taking into account political ideologies (Crawford, 2017). One limitation is that, in these studies, we used a general environmental denial scale but it has recently been shown that studying specific forms of denial can lead to different outcomes (Wullenkord and Reese, 2021). It is all the more consistent that in the future, better use of denial forms will allow for better identification of psychological mechanisms in response to the environmental threat.

In addition, results are consistent with a considerable literature about the positive associations between right political orientation, system justification and environmental denial (e.g., Feygina et al., 2010; Häkkinen and Akrami, 2014). Thus, we found that a right political orientation is associated with higher tendencies to justify the system. This positive association contradicts recent results collected from a large sample of the French population (Langer et al., 2020) where authors found a negative association between political orientation and system justification tendencies ($r = -0.17$, $n = 22\ 777$). It indicates that people with left political orientation are more likely to justify their system than people with right political orientation. More recently, Vesper et al. (2022) find a positive, but non-significant correlation ($r = 0.09$, $n = 463$). One explanation is based on the nature of our sample, more precisely on the repartition of political orientation that is mostly centered and left oriented. Indeed, it is possible that our sample is more representative of young and left-oriented perceptions on the political spectrum. This implies that inter-individual differences that influence system justification tendencies should be understood as particularly dependent on the social, political and economic context.

Conclusion

To conclude, although our data did not show an effect of environmental threat induction, they are consistent with

previous associations found in the literature such as the positive link between right political orientation, system justification and environmental denial. This research contributes to both debates on the effects of environmental threat and on the role of political orientation to predict both system justification and environmental denial. It is therefore important to conduct more experimental studies on those questions, especially in different political contexts, and to use better definitions of environmental threat. One possibility is to investigate some political features that lead to the perception of threat from climate change messages. As Clarke et al. (2019) argued, a better definition of the threat will help to make better definitions and choice of outcomes. A good start would be to detail what is threatening, who will be threatened and when/where does it happen. Finally, we hope that this research can provide a first exploration of these issues in the French political context and that it can encourage people to investigate which aspects of climate change are perceived as threatening.

Data availability statement

The original contributions presented in the study are publicly available. This data can be found here: https://osf.io/9k86r/.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

Both authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Eco-anxiety in children: A scoping review of the mental health impacts of the awareness of climate change

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Background: Youth are increasingly aware of the negative effects of climate change on the planet and human health, but this knowledge can often come with significant affective responses, such as psychological distress, anger, or despair. Experiencing major "negative" emotions, like worry, guilt, and hopelessness in anticipation of climate change has been identified with the term eco-anxiety. Emerging literature focuses on adults' experience; however, little is known about the ways in which children and youth experience eco-anxiety.

Objectives: The aim of this review was to: (1) identify the available evidence on the topic of eco-anxiety in children, (2) clarify the mental health consequences brought by the awareness of climate change in this population, and (3) identify knowledge gaps in the literature and considerations for future research.

Methods: Given that the research on the topic of eco-anxiety in children is limited, that there are very few randomized controlled trials, and that the goal is not to analyze individual studies in-depth, a scoping review was used. Keywords pertaining to the themes of eco-anxiety, climate change and children (aged < 18 years) were used as search terms in five databases. Journal articles using qualitative and quantitative methods, as well as gray literature were examined by two independent reviewers. A descriptive-analytical method was used to chart the data that emerged from the literature. Eighteen articles were considered in the final analysis.

Results: Evidence confirms that children experience affective responses and eco-anxiety in reaction to then awareness of climate change. Mental health outcomes include depression, anxiety, and extreme emotions like sadness, anger, and fear. Youth from vulnerable communities, like indigenous communities, or those who have strong ties to the land are often identified as being emotionally impacted by climate change. The literature analyzed also describes how children and youth are coping with eco-anxiety, including

maladaptive (e.g., denial) and adaptive responses (such as constructive hope, used as a positive coping mechanism). Preliminary considerations for parents, teachers and educators, mental health care providers, school systems, adults and people of power include adding age-appropriate climate education to the school curriculum, considering youth's emotions, and promoting healthy coping through empowerment. Important gaps exist in the definition of eco-anxiety in youth, as various characterizations of this emerging concept are found across articles.

KEYWORDS

eco-anxiety, children, youth, mental health, climate change, scoping review

Introduction

Although climate change has been a subject of interest since the 1960s (for example, see Flohn, 1961; Benton, 1970), it has undeniably become the challenge of the 21st century. The Intergovernmental Panel for Climate Change (IPCC), which has published scientific assessments about climate change since 1990, issued a report presenting different scenarios for the future, outlining the inevitable consequences humans will face in the next years (Masson-Delmotte et al., 2021). In all these scenarios, it is unavoidable that temperatures will reach an increase of 1.5 degrees Celsius by 2040 (with 1850–1900 being the baseline). As such, there is scientific consensus of anthropogenic (i.e., human-made) climate change (Costello et al., 2009; Hoegh-Guldberg et al., 2019; Masson-Delmotte et al., 2021). This phenomenon not only affects biodiversity in general, but it also has significant physical impacts on humans (Hoegh-Guldberg et al., 2019; Masson-Delmotte et al., 2021). For example, researchers have found that pollution can cause acute respiratory problems (Doherty et al., 2017; Orru et al., 2017), some even linking the increase in viral infections to the destruction of ecosystems (Woolhouse, 2002; Everard et al., 2020).

The Media and Climate Change Observatory (MeCCO) published a special issue on the particular attention that was brought to the topic of climate change in 2019 (Nacu-Schmidt et al., 2020). They highlighted how the media devoted much attention to the increasing number of fires around the world, the rising sea levels, and the United Nations climate talks. These events from 2019 also coincided with the global youth-led climate strikes and the appearance of Greta Thunberg as a public personality. Indeed, people around the world were becoming worried about the future of the planet and the increasingly frequent extreme weather events. As there was a clear consensus of the physical effects of climate change (on humans, biodiversity, and the Earth), people were realizing that there were also emerging mental health impacts (Arcanjo, 2019; Ballew et al., 2019). Furthermore, in the midst of the COVID-19 pandemic, people are facing two major crises which both take a toll on mental health (Généreux et al., 2020; Rosen, 2020; Samji et al., 2021). Not only are youth particularly affected by restrictive measures (quarantine, school closures), but they are also concerned for their future when they integrate messages of emergency and crises relative to climate change (Pickard, 2021; Romeu, 2021).

Mental health and climate change

Berry et al. (2010) propose three categories of mental health impacts of climate change: direct, indirect, and vicarious. Most research has focused on the direct impacts of climate change on mental health, which are those that happen after experiencing an extreme weather event such as a flood, an earthquake, or a hurricane. These major life disruptions can lead to post-traumatic stress disorder (PTSD), depression disorders, anxiety disorders, substance use disorders, and suicidal thoughts (Berry et al., 2010; Hayes et al., 2018; Cianconi et al., 2020). Indirect impacts of climate change can also affect mental health through consequences on the economy, migration, damage to physical and social infrastructure, food and water shortages, and conflict; all of which have been linked to stress, grief, anxiety and depression (Akresh, 2016; Hayes et al., 2018). However, even without experiencing the direct or indirect effects of climate change, many feel distress simply by being aware of the global environmental crisis (Pihkala, 2018).

The focus of this review will be on these *vicarious* reactions, or the emotional and affective impacts of the awareness of climate change lived through knowledge about the issue. In other words, witnessing the effects of climate change through the media and other information sources without experiencing it firsthand can also have an impact on mental health. There is much less research on this form of vicarious reaction to climate change, but scholars are starting to report that people are feeling overwhelmed by the situation, leading to panic attacks, insomnia, or obsessive thinking (Clayton et al., 2017; Usher et al., 2019). Knowing about climate change and its consequences can bring upon many emotions such as guilt, sadness, and anger, which all make up *eco-anxiety* (Pihkala, 2020). The American Psychological Association (APA) recognizes eco-anxiety as a "chronic fear of environmental doom" (Clayton et al., 2017).

Researchers have found that experiencing low levels of anxiety and emotions in the face of climate change is a normal response to a stressful reality (Reser and Swim, 2011; Verplanken and Roy, 2013; Clayton et al., 2017; Scheirich, 2020). As such, there is no mental health diagnosis of eco-anxiety, and it is not considered a pathological problem. However, some people who are experiencing eco-anxiety will feel genuine distress that can limit their daily activities and lead to serious depressive and anxious symptoms (Jones et al., 2012; Doherty, 2018; Pihkala, 2018; Kaplan, 2020; Rosen, 2020). Thus, some researchers are now suggesting that the concept of eco-anxiety may be placed on a spectrum: on one end, these strong emotions may lead to action and mobilization, empowering people to change their habits and help the planet; on the other end, eco-anxiety may lead to a debilitating paralysis when facing the immensity of the problem (Wolf and Moser, 2011; Wolfe and Tubi, 2019; Pihkala, 2020). In short, as knowledge about climate change can lead to an increase in pro-environmental behaviors, it can also lead to paralyzing anxiety and denial (Albrecht et al., 2007). People may move along this spectrum depending on many factors, including their emotional availability, social support network, and the world's global situation (Berry et al., 2010; Clayton et al., 2017; Hayes et al., 2019). This broader definition of eco-anxiety acknowledges that strong emotional reactions to the current climate crisis are normal and could lead to pro-environmental behaviors (Searle and Gow, 2010). Whereas, an overly restricted definition of eco-anxiety might lead to it being pathologizing when people could use the emotions elicited by eco-anxiety positively as a motivation for taking action and learn adaptive coping strategies (Verlie, 2019). This is especially important since the problem of climate change is unlikely to disappear in the next few years (Masson-Delmotte et al., 2021).

Some scholars have suggested that the term eco-anxiety may not be the most suited to describe this phenomenon since the name seems to refer solely to anxiety when its definition encompasses many other emotions (Arcanjo, 2019; Huizen, 2019; Ojala, 2019; Pihkala, 2020; Raypole and Legg, 2020). Nonetheless, given the popularity of the term, this review employs the broad definition of eco-anxiety, referring to this key concept as any significant emotional response to the awareness of climate change.

Literature is rapidly emerging on eco-anxiety in adults, but very little remains known about how younger people and children experience the awareness of climate change. Children around the world are growing up in an uncertain world where messages of "doom and gloom" about climate change often dominate the public discourse and media (Engelhaupt, 2017). In Australia, a survey of 600 children between 10 and 14 years-old children revealed that "44% of children are worried about the future impact of climate change" and "one quarter of children worry that the world will end before they get older" [(Tucci et al., 2007). p. 13]. Learning about climate change without acquiring the tools to cope with the emotions that accompany this knowledge may lead to hopelessness and denial (Ojala, 2012b). Nonetheless, general knowledge about climate change amongst younger people seems low, but their level of concern and anxiety is high (Erkal et al., 2012; Corner et al., 2015). The mental health consequences of eco-anxiety in children are not yet well understood. Thus, a review of the current state of the literature may help to understand the extent of the academic knowledge on this subject.

Objectives

Eco-anxiety may very well be a public health challenge in the years to come; thus, it is important to continually stay up to date with the findings. Scoping reviews are a relevant methodological tool when the research on the topic is rapidly growing, that there are very few randomized controlled trials, and that the goal is not to analyze individual studies in-depth (Munn et al., 2018). As such, the objective of this study was to conduct a scoping review of the relevant articles on the subject of eco-anxiety in children and youth. The broad guiding research question was: What is the nature of the evidence on eco-anxiety in youth and children? Although the phenomenon of eco-anxiety is gaining popularity in research, there is a lack of understanding of the vicarious psychological impacts of climate change in youth and children (Cunsolo et al., 2020). The aims of this study were to: (1) explore the terminology used to describe eco-anxiety in youth and children specifically, (2) look at the evidence of eco-anxiety in this population, and (3) identify the knowledge gaps in this research topic and highlight specific considerations in relation to future research. An initial search of the literature revealed that evidence on the topic of eco-anxiety focused on initial theories and many suggested specific recommendations in relation to children coping with climate change awareness. Although providing recommendations may be precocious, given that eco-anxiety in children is a rapidly emerging topic, it is important to focus on ways to support mental health. Nonetheless, one must bear in mind that these recommendations are based on knowledge that is preliminary in nature, consequently, they must be analyzed with caution. Hence, these recommendations that emerged are regarded as specific considerations for certain actors in children's lives that should guide future research.

Methods

Protocol

The study protocol for this review was developed using the methodological framework suggested by Arksey and O'Malley (2005), which was further refined by Levac et al. (2010) and was guided by the Preferred Reporting Items for Systematic

Reviews and Meta-Analyses for scoping reviews (PRISMA-ScR) statement (Tricco et al., 2018).

Inclusion and exclusion criteria

The present review considered studies published between January 1st, 2000, and March 3rd, 2021, in English and in French, from around the world. The lower date limit was selected given that eco-anxiety and the urgency of the climate crisis are topics that have gained focus since the beginning of the 21st century (Pihkala, 2020). The population of interest for this scoping study were children and youth. The United Nations Convention on the Rights of the Child definition of children was used to identify our population as "human beings below the age of 18" (United Nations., 1989).

We operationalized our review based on the work from a prominent figure in the field, Pihkala, who conducted a systematic analysis to clarify the nature of the phenomena of eco-anxiety, including articles from social and political sciences, existential psychology, psychodynamic perspectives, and other anxiety theories (Pihkala, 2020). Indeed, they define the concept of eco-anxiety as "a general term for difficult feelings because of the ecological crisis" (p. 14). Common emotional responses include anger, guilt, sadness, and hopelessness (Clayton et al., 2017; Pihkala, 2018). Similarly, we broadly defined the concept of eco-anxiety as any strong emotion pertaining to the awareness of climate change. Keywords included hopelessness, solastalgia, eco-phobia, eco-depression, despair, eco-angst, and eco-guilt. These keywords were found in literature on the topic of eco-anxiety pertaining to adults, and in the review by Pihkala (2020).

The exclusion criteria were selected based on the chosen definition of eco-anxiety: an anticipatory emotional response to climate change and on the chosen population of children. Thus, the articles included needed to (1) involve children, (2) mention mental health impacts of climate change, and (3) these impacts needed to be in response to the awareness of climate change. As such, excluded articles that did not meet criteria were those that only involved people above 18 years old; spoke of physical, economical, or social impacts without mentioning mental health; or only touched on the effects from after a climate-related natural crisis such as a tornado or a tsunami.

Types of sources

Given that the aim of a scoping study is not to evaluate the quality of the evidence, but to summarize the evidence and make recommendations, quantitative, qualitative, observational, mixed methods, and review studies, as well as opinion papers, news articles and dissertation theses were included. Research protocols and scale elaborations were not included, as they did not inform on the nature of the evidence.

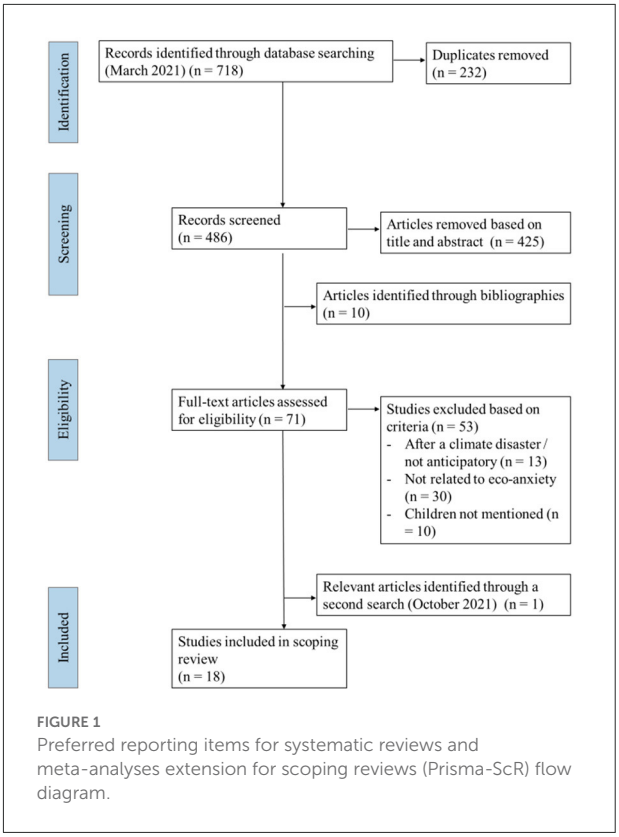

FIGURE 1
Preferred reporting items for systematic reviews and meta-analyses extension for scoping reviews (Prisma-ScR) flow diagram.

Search strategy

To help identify keywords and index terms, an initial search in APA PsycInfo was performed with an information specialist. This informed the full search strategy. The information sources were selected based on the interdisciplinary nature of the concept of eco-anxiety, with a particular interest for psychology and education sources. The selected electronic databases were APA PsycInfo, Education source, ERIC, GreenFILE, MEDLINE, Psychology and Behavioral Sciences Collection, SocINDEX, Sage Journals and ProQuest. Furthermore, gray literature (non-published materials) was identified through a simple Google search (i.e., not scholar), using the first five pages of the results. Materials in English and French were included, given these were the languages understood by the reviewers. The final search strategy for the APA PsycInfo database can be found in Appendix A. Key articles' bibliographies (Ojala, 2012a; Strife, 2012) were analyzed to identify further relevant literature.

Study selection

A total of 718 sources were identified in the full search stage and 486 sources remained after duplicates were removed. Identified articles were saved into Mendeley (version 1.19.8) and uploaded to Covidence (version v2532 1ea49715) for two

reviewers to independently screen the articles. The inclusion and exclusion criteria were specified in the software and were used in the level 1 and level 2 screenings. The two independent reviewers first screened the titles and abstracts, and the percentage of agreement was 81% for this step. Next, the same two reviewers independently screened the full text (percentage of agreement = 82%). For each step, the reviewers met to discuss any conflicts in their decisions. If needed, a third reviewer was included to help decide on inclusion. Please see Figure 1 for the flow diagram based on PRISMA (Tricco et al., 2018). A total of 17 articles remained.

Given that eco-anxiety is an emerging area of research with an increase in publications in the past year, a second search was performed using the same keywords and databases, with the aim of including any newly published article between March 2021 and October 23rd, 2021. A total of 375 articles were identified, 13 titles and abstracts were screened, and one met the full inclusion criteria.

Data extraction

Data was extracted from the Covidence software and charted in a pre-defined charting form (see Appendix B) that was further refined. Two independent reviewers charted the relevant information into categories, including author/year, country of publication, research method used, objectives of the study, definition of eco-anxiety, and general impacts of climate change awareness on children's mental health.

Results

This scoping review considered 18 articles that met all inclusion/exclusion criteria. The 18 articles included in the scoping review are identified in the reference list using a "∗" symbol. The data was extracted into a table, exploring the definitions of eco-anxiety, the mental health impacts of climate change awareness on children's mental health, vulnerability or protective factors, and key findings by the authors. Research gaps were then identified and discussed between the researchers.

Study characteristics

All selected studies were published after 2002, with 60% being published after 2016. Half of the articles were from the United States, and the most common research method used was a descriptive design by means of a cross sectional survey (44%) and none of the articles included inferential statistics. A few employed a review type of analysis of evidence (22%), but no formal guide was used (i.e., not systematic, not scoping, etc.). The most common fields of research of the first author were education (39%) and psychology (28%). Two articles were from non-academic sources (newspapers). The study characteristics can all be found in Table 1, and the methodological information (methods, sample size and age) for each article can be found in Table 2.

TABLE 1 Study characteristics.

Study characteristics ($N = 18$)		Count (%)
Year of publication		
	2002-2005	2 (11.1%)
	2007	1 (5.6%)
	2012-2013	4 (22.2%)
	2016-2019	4 (22.2%)
	2020	6 (33%)
	2021	1 (5.6%)
Country		
	United States	9 (50%)
	Sweden	3 (16.7%)
	England	1 (5.6%)
	Finland	1 (5.6%)
	Australia	1 (5.6%)
	Australia and Canada	1 (5.6%)
	Canada and Taiwan	1 (5.6%)
	Mixed	1 (5.6%)
Research method		
	Descriptive cross-sectional survey (quantitative)	8 (44.4%)
	Review	4 (22.2%)
	Interviews (qualitative)	2 (11.1%)
	Newspaper article	2 (11.1%)
	Observational (qualitative)	1 (5.6%)
	Analysis of written letters (qualitative)	1 (5.6%)
Field		
	Education	7 (38.9%)
	Psychology	5 (27.7%)
	Environmentalism	3 (16.7%)
	Journalism	2 (11.1%)
	Nursing	1 (5.6%)

Terminology used

Our first objective was to explore the terminology used in the selected articles around the theme of eco-anxiety in literature focused on children. The term eco-anxiety was only employed in three articles (16%) (Pinto and Grove-White, 2020; Plautz, 2020; Hickman et al., 2021). Authors Pinto and Grove-White (2020) started their article with the sentence "Eco-anxiety is on the rise and is affecting children of all ages, including primary children"

TABLE 2 Methodological information arranged per author.

Reference	Methods	Sample size	Sample age
Hickman et al. (2021)	Cross sectional survey	$n = 10\,000$	16–25 years old
Chalupka et al. (2020)	General review (no specific method)	None mentioned	"Children"
Pinto and Grove-White (2020)	Observational	One primary school (sample size not further specified)	Primary school aged children (5–12 years old)
Plautz (2020)	Newspaper article	None mentioned	12–25 years old
Ratinen and Uusiautti (2020)	Cross-sectional survey (descriptive design)	950	11–17 years old (M = 13.6)
Taylor and Murray (2020)	Newspaper article	None mentioned	"Children" and "Youth"
Zummo et al. (2020)	Qualitative analysis of letters	$n = 350$	12–18 years old
Li and Monroe (2019)	Cross-sectional survey (descriptive design)	$n = 728$	13–18 years old (9–12th graders)
Burke et al. (2018)	General review (no specific method)	None mentioned	"Children"
Boggs et al. (2016).	General review (no specific method)	None mentioned	"Children"
Stevenson and Peterson (2016)	Cross-sectional survey (descriptive design)	$n = 1486$	11–15 years old
Ojala (2013)	Cross-sectional survey (descriptive design)	$n = 321$	M = 17.2 years old
Ojala (2012a)	Cross-sectional survey (descriptive design)	Late childhood ($n = 90$) Adolescents ($n = 146$)	Late childhood (M = 11.7 years old) Adolescents (M = 16.4 years old)
Ojala (2012b)	Cross-sectional survey (descriptive design)	$n = 293$	12 years old
Strife (2012)	Semi-structured qualitative interviews	$n = 50$	10–12 years old
Sobel (2007)	General review (no specific method)	None mentioned	"Children"
Nagel (2005)	Phenomenological interviews	$n = 40$	7th grade (12–13 years old)
Huang and Yore (2005)	Cross-sectional survey (descriptive design)	$n = 761$	5th grade (10–11 years old)

(p. 252), but they did not define the term. The article they cited while using the term eco-anxiety was a BBC Newsround survey that found that 70% of 8- to 16-year-olds report feeling worried about the state of the planet (Atherton, 2020). As such, it could be extrapolated that these authors perceived eco-anxiety as significant worry about the state of the planet because of climate change. In their news article published in the Washington Post, Plautz (2020) also used the term without explicitly defining it. They referred to eco-anxiety as a type of anxiety felt (by children and adolescents) in response to climate change, and significant worry about the planet. For their part, Hickman et al. (2021) defined eco-anxiety as "distress relating to the climate and ecological crises" (p. 3). They also included many different emotions as being involved in eco-anxiety, including "worry, fear, anger, grief, despair, guilt, and shame, as well as hope." (p. 3) In general, authors from these three articles seemed to agree that worry is a key component of eco-anxiety in children.

Other terms related to eco-anxiety were also used. These included ecophobia, which was referred to as being "fearful of environmental problems" [(Ratinen and Uusiautti, 2020). p. 11], a sense of "ennui and helplessness" caused by the "overwhelmingness of environmental problems" [(Sobel, 2007). p. 17], and a "broad fear of environmental deterioration and environmental problems" [(Strife, 2012). p. 37]. Li and Monroe (2019) use the terms environmental grief and eco-despair without defining them. The term climate anxiety was used by authors to refer to as "distress relating to the climate and ecological crises" [(Hickman et al., 2021). p. 3] and as "the fear that the current system is pushing the Earth beyond its ecological limits" [(Taylor and Murray, 2020). p. 3].

Evidence of eco-anxiety in children

Our second objective was to identify the evidence of eco-anxiety in children. Although the term eco-anxiety was not frequently used, many of the articles mentioned the emotions reported by children and youth that were included in the definition of eco-anxiety. To identify the emotions and psychological states reported, a content analysis was used (Erlingsson and Brysiewicz, 2017). Each passage was coded to indicate emotions felt by children or youth. The authors of the included articles mentioned that children and youth feel fear, anger, hopelessness, and sadness as they become aware of climate change and its consequences. However, worry and hope were the two emotions that were most reported in the selected articles. For the occurrences coded as being an emotional reaction of children to the awareness of climate change, please see Table 3.

Furthermore, data was charted to describe how each article interpreted the impacts of climate change awareness on children's mental health, as well as the vulnerability and protective factors (see Table 4). Many indicators suggested that

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TABLE 3 Coding frequency for each emotion/state in all the selected articles.

Emotion/state	Number of relevant codes (% of codes)	Number of articles that mention (%)
Worry	88 (26.9%)	14 (78%)
Hope	68 (20.8%)	12 (67%)
Fear	47 (14.4%)	12 (67%)
Anxiety	43 (13.1%)	15 (83%)
Anger	23 (7%)	12 (67%)
Despair	16 (4.9%)	7 (39%)
Sadness	14 (4.3%)	10 (39%)
Hopelessness	14 (4.3%)	9 (50%)
Guilt	11 (3.4%)	5 (28%)
Depression	3 (0.9%)	2 (11%)

children are experiencing eco-anxiety. Several authors indicated that children are feeling worried in their daily lives. For some, this can manifest as a concern for children and people from other countries who are already experiencing the impacts of climate change (Burke et al., 2018; Chalupka et al., 2020; Taylor and Murray, 2020). For others, this worry pertained to their own future, anticipating a significant loss of biodiversity, an increase in pollution, and perhaps even the end of the world in their own lifetime (Huang and Yore, 2005; Nagel, 2005; Strife, 2012; Ojala, 2013; Burke et al., 2018; Chalupka et al., 2020; Plautz, 2020; Ratinen and Uusiautti, 2020; Hickman et al., 2021). This considerable worry about the future of the planet and how the world will be when they grow up can lead to hopelessness and pessimism. This worry is also closely linked to emotions of fear for their future (Huang and Yore, 2005; Strife, 2012; Boggs et al., 2016; Burke et al., 2018; Pinto and Grove-White, 2020; Plautz, 2020; Zummo et al., 2020), anger that their generation must deal with this problem (Huang and Yore, 2005; Ojala, 2012a; Strife, 2012; Boggs et al., 2016), general states of anxiety (Ojala, 2012b; Boggs et al., 2016; Stevenson and Peterson, 2016; Burke et al., 2018; Pinto and Grove-White, 2020; Plautz, 2020; Ratinen and Uusiautti, 2020; Taylor and Murray, 2020) or even panic attacks (Plautz, 2020).

However, there is also evidence that indicates that youth and children experience hope in the context of climate change awareness. Two studies found that worry and hope were positively correlated (Stevenson and Peterson, 2016; Li and Monroe, 2019), and that hope was also associated with action (Ojala, 2012a; Stevenson and Peterson, 2016; Burke et al., 2018).

A key finding that surfaced from these articles is the research on how children cope with climate change. In her articles, Ojala (2012a,b, 2013) explores three different types of coping used by children: (1) problem focused coping, which is actively trying to do something about climate change by doing something concrete, like thinking about the problem, searching for information, and directly acting upon it; (2) emotion-focused-coping, which is developing strategies to get rid of the negative emotions caused by the problem, such as de-emphasizing the threat, denial, distancing oneself from the problem through distraction and avoidance, finding social support, and hyperactivation of emotions; and (3) meaning focused coping, which is evoking positive emotions through beliefs and values while acknowledging the problem of climate change and finding meaning in a difficult situation when the problem cannot be solved at once, for example by reframing the situation in a positive manner, focusing on what is hopeful about the situation, and trusting different sources. Ojala (2012a) found that the most common coping strategy in children, adolescents and young adults was using emotional distancing from climate change (i.e., emotion-focused coping). However, when it came to promoting hope, meaning-focused coping was the most efficient coping mechanism because it activates positive emotions without ignoring the negative ones, which was associated with general positive affect and pro-environmental behavior (Ojala, 2012b). These findings were cited in other articles that also acknowledged the importance of hope in children (Stevenson and Peterson, 2016; Burke et al., 2018; Li and Monroe, 2019; Ratinen and Uusiautti, 2020; Zummo et al., 2020; Hickman et al., 2021). For example, Li and Monroe (2019) found a positive association between concern and hope in youth. This suggests that there could be a presence of strong negative emotions toward climate change in children and youth without the presence of distress, supporting the spectrum hypothesis of eco-anxiety.

Reported vulnerability factors that are associated with increased worry included the following: using problem-focused coping mechanisms (Ojala, 2013), being a girl (Stevenson and Peterson, 2016; Ratinen and Uusiautti, 2020), not having the possibility to take action (Pinto and Grove-White, 2020), having a strong connection to nature or the land, as can be seen in indigenous communities (Chalupka et al., 2020), and believing that the governmental responses are unsatisfactory (Hickman et al., 2021).

Evidence from the articles also suggested potential protective factors that could foster hope in children. For instance, having a sense of agency (Sobel, 2007; Pinto and Grove-White, 2020; Hickman et al., 2021), trusting technological advances (Strife, 2012), feeling a sense of purpose and using meaning-focused coping mechanisms (Ojala, 2012a,b, 2013), being involved in activism and having positive images of the future (Burke et al., 2018), as well as feeling empowered (Taylor and Murray, 2020) were all associated with positive management of emotions. Moreover, being a girl was associated with higher hope, and was thus also identified as a protective factor (Stevenson and Peterson, 2016; Li and Monroe, 2019). The vulnerability and protective factors by author can be found in Table 4.

TABLE 4 Charted scoping review data from all 18 papers, arranged chronologically and by author.

Authors	Impact of climate change awareness on children's mental health	Vulnerability factors	Protective factors
Hickman et al. (2021)	A significant amount of youth and young adults feel very worried about climate change and report feeling afraid, sad, anxious, angry, powerless, helpless, and/or guilty. These strongly felt emotions impacted the daily lives of 45% of this sample.	Distress was higher when youth believed that government responses are inadequate.	Coping skills, validation, respect of their views/feeling heard, and agency to act.
Chalupka et al. (2020)	Children from "high-income developed nations" are familiar with the impacts of global climate change. This awareness causes significant concern and internal conflicts given their perceived privilege.	Children from indigenous and subsistence communities or that have strong ties to the land may experience more concern for the planet.	None mentioned.
Pinto and Grove-White (2020)	Information about climate change that is not adapted to children can lead them to feel scared and anxious about the situation. They need opportunities to deal with these emotions and act for the environment.	Fear without the possibility of action can lead to significant anxiety and feelings of hopelessness.	Primary schools supporting climate action (feelings of coherence between values/what is learnt and institution's choices).
Plautz (2020)	Climate change is an additional burden to children. Some children may have trouble coping with their daily stress combined to the awareness of climate change, potentially leading to hopelessness, and wondering why they should keep going to school. Some teenagers express fear for their future, panic, sadness, and injustice that their generation must deal with the problem of climate change and its consequences.	Being a child or an adolescent, as they become aware of the task ahead and the consequences of climate change, they will have to deal with in their lifetime, can make them experience significant distress and anxiety.	None mentioned.
Ratinen and Uusiautti (2020)	Students experience pessimism and doubt that the future will change to respond to climate change. This lack of hope can lead to depression and anxiety.	Girls have a higher sense of responsibility to mitigate climate change and they are less confident of the effectiveness of science than boys, making them more vulnerable to anxiety and pessimism.	Fostering constructive hope and optimism in children can help them face the challenge of climate change.
Taylor and Murray (2020)	Children are aware of global climate change at a very young age and can become stressed or anxious.	None mentioned.	Empowering children to take action for the environment can help them reduce their anxiety.
Zummo et al. (2020)	Discourses of doom that often taint the media coverage of climate change and can lead to children experiencing fear and anxiety, leading to inaction, loss of hope and a later focus on the negative.	None mentioned.	None mentioned.
Li and Monroe (2019)	Students' concern about climate change and hope are positively correlated. Being aware of and concerned about the environmental crisis leads to finding strategies to be more effective and cope with the emotions.	None mentioned.	Older girls had the highest levels of hopefulness in this sample.
Burke et al. (2018)	Many young people experience worry, fear, and anxiety about the consequences of climate change on their future lives. Children also express concern about the impacts of climate change on children who live in developing countries. Climate change awareness can also lead to despair, denial, and inaction, as they are unable to cope with the extent of the problem.	None mentioned.	Activism and implication in youth climate movements can help children manage their anxiety (action). Positive images of the future with achievable actions can help children build hope.

(Continued)

TABLE 4 Continued

Authors	Impact of climate change awareness on children's mental health	Vulnerability factors	Protective factors
Boggs et al. (2016)	Children ask questions about their personal impact on the planet and wonder how they can make a difference given the size of the problem. As such, they can experience anxiety, fear, and anger.	None mentioned.	None mentioned.
Stevenson and Peterson (2016)	Concern about climate change may be a positive way to lead to action. It is particularly important that children feel concern in response to climate change because they will have to face the consequences of climate change during their lifetime and are particularly vulnerable to despair. As such, anxiety and worry in adolescents could be linked to critical thinking and engagement in solutions. Nonetheless, this mechanism is only at work if the concern and anxiety is accompanied by hope	Girls experience higher levels of concern.	Girls are also more hopeful.
Ojala (2013)	Children may experience worry, negative affects, and/or anxious and depressive feelings in response to their awareness of climate change.	Children who cope using problem-focused coping mechanisms may experience more negative affect.	Children who cope using meaning focused coping may experience more positive affect and higher life satisfaction.
Ojala (2012a).	Children and adolescents are worried and feel negative emotions about climate change. Emotions mentioned include guilt, anger, sadness, and hopelessness.	Adolescents are more vulnerable to experiencing pessimism.	Children and adolescents who cope using meaning focused coping feel less helpless.
Ojala (2012b).	Children seem to significantly worry about global climate change and many solely cope by searching for information about ways to solve the problem (problem-focused coping) which, when used to cope with an uncontrollable situation, can lead to lower mental wellbeing.	None mentioned.	Having a sense of purpose may reduce the feelings of worry in children. Using other coping mechanisms combined to problem-focused coping can reduce anxiety and negative emotions.
Strife (2012)	Children express sadness, fear, anger, pessimism, and feel overwhelmed by the awareness of climate change. Some children report crying, having nightmares, feeling extreme sadness and fear that the world might end, some fear for their own children, and other say they want to scream when hears about climate change.	None mentioned.	Trust in technology was associated to higher hope.
Sobel (2007)	Environmental education can lead children to feel overwhelmed and worried.	None mentioned.	When children think their behavior makes a difference (feeling of agency), they are less worried.
Nagel (2005)	Many students expressed concern, and children are susceptible to negative feelings because of environmental information they may get in the media. Some children experienced learned hopelessness (deterioration of the environment is at a point of no return), and this led to inaction and apathy (lack of interest and concern), action paralysis, and disempowerment.	None mentioned.	None mentioned.
Huang and Yore (2005)	Children express fear, anger, and worry about pollution and environmental problems.	None mentioned.	None mentioned.

TABLE 5 Considerations per author.

Social agent	Considerations	Authors
Teachers, educators	Climate action should be student-led	Pinto and Grove-White, 2020
	Promotion of realistic optimism, realistic positive thinking	Ojala, 2013; Ratinen and Uusiautti, 2020
	Consider the sociopolitical context and/or students' backgrounds when discussing climate change within the classroom	Stevenson and Peterson, 2016; Zummo et al., 2020
	Incorporate solutions into classroom discussions pertaining to climate education	Sobel, 2007; Ojala, 2012a, 2013;
	Give discussion opportunities to come up with ways to act, or directly give students suggestions of concrete pro-environmental actions they can take	Stevenson and Peterson, 2016; Li and Monroe, 2019; Plautz,
	Give a sense of agency	2020; Zummo et al., 2020
	Use literature as a tool to discuss climate change with children: • Books should be carefully selected • Several resources should be used • Use books as a medium to create a dialogue, and combine this dialogue with students' perspectives and thoughts	Boggs et al., 2016
	Emphasize collective action	Ojala, 2013; Stevenson and Peterson, 2016; Pinto and Grove-White, 2020
	Give students the opportunity to engage and work with one another when addressing the issue of climate change	Ojala, 2013
	Do not hide the realities of climate change from students	Stevenson and Peterson, 2016
	Validate students' emotions, encourage students to openly discuss their feelings, consider their emotions	Ojala, 2012a, 2013
	Promote meaning-focused coping (e.g., realistic positive thinking, invite guest speaker who is actively engaged in climate change)	Ojala, 2013
	Balance encouragement of problem-focused coping with that of positive thinking, optimism, and trust in others	Ojala, 2012b
	Encourage students to seek different ideas of what the future will look like (not just from media and scientific sources, but also through art and cultural activities)	Ojala, 2012b
	Give students the opportunity to engage in environmental actions (not just discuss)	Strife, 2012
	Encourage individual and critical thinking about the environment and climate change in the following ways: • Treat learning as an educational journey, rather than imposing one's own views and values • Give students the tools and skills they need to understand and critically think about policies and ideas pertaining to the environment • Give students the chance to participate in debates	Nagel, 2005
School systems	Make changes to the school curriculum with a proposed framework called the Learn-Think-Act, while including the following: • A mental health component • Material that is age-appropriate, gender-sensitive, and intersectional • Content that involves both local and global perspectives • A focus on collectivity	Pinto and Grove-White, 2020
	Teach climate education at younger ages, rather than starting when children are older	Pinto and Grove-White, 2020
	Establish specific school-based program (i.e., Ladder of Responsibility) within schools, whereby each grade level has its own set of age-appropriate responsibilities, these tasks can require daily or weekly care or dedication on the children's part, and they are incorporated into the curriculum in various ways.	Sobel, 2007
	Encourage teaching children to engage in environmental behaviors before introducing them to knowledge that may become overwhelming and not have as much of an effect	Sobel, 2007
	Encourage nature experiences and exposure to nature; in climate education, have children engage with the environment through behavior	Sobel, 2007

(Continued)

TABLE 5 Continued

Social agent	Considerations	Authors
Parents	Give child the space to share their concerns and emotions regarding climate change; a parent does not need to be an expert. Validate child's emotions and feelings concerning the issue Balance negative information with positive information (3 positives for each negative) Encourage child to take action, and when doing so, focus on local perspectives and tangible actions. Come up with attainable family goals to take action.	Taylor and Murray, 2020
Parents and teachers/educators	For children or students who frequently watch television, a space of conversation should be opened up by the adult, for children to openly share thoughts, feelings, and concerns	Strife, 2012
People in positions of power (e.g., politicians), adults	Take responsibility and action in the climate crisis; it should not be left to youth alone.	Hickman et al., 2021
	Demonstrate that adults are also taking care of the planet; as an adult, show care and concern	Ojala, 2013; Plautz, 2020
Macro-level, or general population	Establish a systems-based approach regarding climate change and children's mental health, with the following features: • Accessible mental health systems • Psychological first aid training • Public health surveillance and monitoring • Innovative research strategies • Environmental preservation • Social cohesion and public health through community design	Chalupka et al., 2020
	The knowledge that is passed to children should not be stretched outside of the proportion of science. Children should be receiving hopeful, yet realistic messages.	Plautz, 2020
	Provide resources and support to more vulnerable communities, as well as teach community members certain skills so that they can sustainably provide the services (e.g., psychological first aid training)	Burke et al., 2018
	Educate and engage children of Western countries in climate education, seeing that they are more distant from the realities of climate change compared to those of less developed countries, and that their actions have more of an impact (i.e., the contribute more to the causes of climate change).	Burke et al., 2018
Mental health professionals	Advocate, educate others (e.g., colleagues, decision-makers, etc.) about the impacts of climate change, as well as inform others on solutions and concrete actions that can be made	Burke et al., 2018
Researchers (future studies)	Evaluate social context	Ojala, 2012a,b
	Investigate age more closely (e.g., specific to certain age or to children in general)	Ojala, 2012b
	Examine the effects of environmental concern on immediate environmental behavior	Strife, 2012
	Explore the effects of children's concerns and feelings on long-term environmental behavior	Strife, 2012
	Examine and develop ways to build resilience in children in the face of climate change	Burke et al., 2018
	Expand research of the psychological effects of climate change on children to non-developed, non-Western, low- and middle-class countries	Burke et al., 2018
	Determine ways of encouraging children to have positive images of an attainable zero or low carbon future, as well as investigate how these images can promote mental wellbeing and healthy coping. Then with this, also determine how adults can promote these ways of coping.	Burke et al., 2018

Knowledge gaps and considerations for future research

Our last objective was to identify knowledge gaps and important considerations in the literature to guide future research and help people already supporting children who are experiencing eco-anxiety. This scoping review brought to light many recommendations on how to maintain and protect the mental health of children and adolescents in the face of climate change. These recommendations are addressed to various groups of people and levels of society, including teachers and educators, parents, policy makers and political figures, school curriculum administrators, mental health professionals, fellow researchers, as well as the general public. All the recommendations by authors are also reported in Table 5. As mentioned previously, these recommendations are based on preliminary research and should be analyzed with caution. The knowledge gaps found by the authors of the included articles are highlighted as considerations for researchers.

Parents

Starting at the micro-level of society, even though they may not feel like they are experts in this area, parents play a significant role in their children's relationship with climate change (Taylor and Murray, 2020). In their article, Taylor and Murray (2020) give the following tips for parents when it comes to discussing and addressing the effects of climate change with their child: (1) provide the child with opportunities to openly share their emotions and concerns regarding climate change; (2) validate the child's emotions and feelings, without minimizing them; (3) balance negative information with positive information, more specifically, for each negative piece of information, give three positives; (4) when engaging younger children in environmental action, focus on the local level and on more tangible acts; and finally (5) come up with attainable goals and complete them as a family. Some of these are consistent with what other authors suggested to teachers and educators. For instance, Ojala (2012a, 2013) recommends that teachers also take the time to validate children's emotions concerning climate change, and that they too provide a safe space for students to openly share their feelings about it.

Teachers and educators

Much of the literature that was identified and explored highlighted several implications for teachers and educators, many of which overlapped with one another. For one, some of the authors advise that teachers make certain considerations prior to initiating discussions in class. For instance, Zummo et al. (2020) recommend that educators consider their students' backgrounds as well and the current sociopolitical context, and that they work with discourses that already exist within these contexts (especially hopeful discourse). When it comes to climate education, Stevenson and Peterson (2016) also highlight the importance of being mindful of students' diverse backgrounds, such as their socioeconomic status (SES), as they found an association between low SES and low levels of pro-environmental behaviors. These authors also suggest that education should incorporate environmental justice components to focus on environmentalism in lower SES communities who are often also the most affected by environmental degradation.

As for curriculum material itself, teachers are encouraged to use carefully selected books and literature to discuss climate change with children; they should use several resources to create a dialogue in combination with the students' own thoughts and ideas (Boggs et al., 2016). In addition, several authors recommend taking action, such as providing students with the opportunity to find and discuss concrete ways to act to improve climate (Ojala, 2013; Li and Monroe, 2019), directly giving students suggestions of concrete actions they can put into practice (Stevenson and Peterson, 2016), as well as give students hands-on opportunities to participate in environmental action (Strife, 2012). Sobel (2007) indicates that this sense of agency can lead to knowledge and motivation for environmental responsibility; and Li and Monroe (2019) mention the importance of children and adolescents feeling that they are making a difference, as they specify that environmental grief alone without any action can lead students to disengage themselves. Having this sense of agency and control over the issue can help them cope with the climate crisis, which can be a protective factor of mental health (Ojala, 2013). Moreover, teaching children to engage in environmental behaviors before introducing them to knowledge can be beneficial, since the knowledge itself may become overwhelming and not effectively promote agency (Sobel, 2007).

Several authors are specific in the types of actions they recommend, such as cycling to school, buying eco-labeled products, and composting. However, according to Pinto and Grove-White (2020), these actions should be student-led. It is also advised that teachers stress collective action, rather than individual action (Ojala, 2013; Stevenson and Peterson, 2016; Pinto and Grove-White, 2020). According to Ojala (2013), making this a collective issue rather than an individual one bears more benefits to students' wellbeing when confronting the climate crisis; giving students a space to work and engage with another to address the problem is one way in which collective action can be put into practice.

Furthermore, it is recommended that classroom discussions be solution focused; however, it is cautioned to not heavily rely on technocentrism, whereby environmental problems are solely solved by new technology. Rather, it is encouraged that other aspects also be considered like the "ethical, moral, political, and social dimensions of climate change" [(Zummo et al., 2020). p. 1222]. Plautz (2020) follows this line of thinking, as they recommend that educators not only teach children facts about climate change and environmental responsibility, but that they also focus on solutions and empowerment, to give students the sense they can change the world.

Acquiring knowledge and finding solutions to climate change are not the only goals that are proposed for climate education. Nagel (2005) encourages individual and critical thinking within the classroom, and outlines the following recommendations for environmental educators: (1) do not pre-establish any values within the classroom, instead, treat learning as an educational journey; (2) give students the tools and skills they need to understand and critically think about policies and ideas pertaining to the environment; and (3) give students the chance to participate in debates, so that they can apply these analytical skills to the information they are exposed to concerning the environment.

Finally, various articles introduce different types of coping used by students and that environmental educators should be aware of. For one, constructive hope is an important topic of investigation when it comes to environmental knowledge

and awareness, as "realistic, positive expectations [hope] closely relate to self-knowledge" [(Ratinen and Uusiautti, 2020). p. 12]. It is recommended that to have this appropriate balance of environmental awareness and constructive hope, realistic optimism should be promoted, as it "helps [children] identify their own attitudes and support trust in not only themselves as environmental actors, but to mankind in general—to provide hope" [(Ratinen and Uusiautti, 2020). p. 12]. This falls in line with Ojala (2013) recommendation that teachers use meaning-focused coping in the classroom, through methods such as realistic positive thinking (as suggested by Ratinen and Uusiautti, 2020), as well as bringing in guest speakers who are engaged in the issue of climate change (e.g., scientists and activists). Problem-focused coping is another method of coping that is mentioned, whereby teachers are encouraged to balance problem-focused coping with encouraging positive thinking, optimism, and trust in others (Ojala, 2012b). For instance, teachers can invite students to seek different ideas of what the future will look like; not just from media and scientific sources, but also through art and cultural activities (Ojala, 2012b).

Mental health professionals

One article acknowledges the role that mental health professionals can play when it comes to children and adolescents' mental health in relation to climate change. Although brief, Burke et al. (2018) recommend that mental health professionals do the following: (1) advocate, (2) educate others (e.g., colleagues, decision-makers, etc.) about the mental health impacts of climate change, and (3) inform others on solutions and concrete actions that can be done.

Meso level: School systems

Pinto and Grove-White (2020) highlight that climate education is key in elementary schools, and that changes need to be made to the school curriculum to prioritize climate education. The authors recommend the addition of a mental health component to the proposed framework (i.e., the Learn-Think-Act framework), and that the content in the material that is being presented is age-appropriate, gender-sensitive, as well as intersectional. Moreover, the content itself should include both local and global perspectives. This proposed addition of climate education would involve both school-based and at-home activities, with some flexibility, beginning while children are still young, rather than when they are older, as it is argued that they are the next generation of change.

Sobel (2007) also recommends a specific program for schools called the Ladder of Responsibility. This school-based program consists of giving children tasks aimed to help the environment throughout their school years. Each grade has their own part of the "ladder," whereby they have their own set of age-appropriate responsibilities, which becomes more challenging with time. These tasks are incorporated into the curriculum in various ways (e.g., in the science classes, but also in arts, math and social sciences through various weekly or daily activities), thus simultaneously fulfilling curriculum requirements for different subjects. Along with this, Sobel (2007) also encourages schools to expose children to nature and encourage lived experiences in nature, thus effectively engaging children with the environment through behavior.

Adults and people of power

According to Hickman et al. (2021), some of the literature mentions that actively participating in the fight against climate change can help with climate anxiety. However, their article suggests that in the case of children, it should not only be up to them to step up. Rather, those in power should take responsibility and action in the climate crisis by "recognizing, understanding, and validating the fears and pain of young people, acknowledging their rights and placing them at the center of policy making." (p. 9). Ojala (2013) and Plautz (2020) support this need for adult accountability, as they encourage adults who surround children to show them that they also care about this pressing issue, and that they too are taking action in caring for the planet.

Adults also hold the responsibility of communicating knowledge and information relating to climate change in a certain manner. For one, the information that is being communicated should not be given to children in a way such that it is stretched outside of the proportion of science; rather, children should be receiving hopeful, yet realistic messages (Plautz, 2020). With this, adolescents should be exposed to the realities of climate change, and adults should not hide these realities from them. Although it is necessary to ensure that hope is not lost and that adolescents do not get discouraged, Stevenson and Peterson (2016) argues that adolescents are able to react to these realities in an action-driven way when given the appropriate tools.

Macro level and the general population

Chalupka et al. (2020) proposes a systems-based approach when it comes to climate change and children's mental health, which includes the following: (1) accessible mental health systems, (2) psychological first aid training, (3) public health surveillance and monitoring, (4) innovative research strategies, (5) environmental preservation, (6) social cohesion and public health through community design. All these measures are aimed to promote children's mental health during the climate crisis. Burke et al. (2018) also focus on the need for psychological support; however, they further recommend that such resources and support be provided to more vulnerable communities. Yet at

the same time, they state that children from Western countries should especially engage in climate education and action, as they are more distant from the realities of climate change compared to those of less "developed" countries, and their actions have more of an impact (i.e., they contribute more to the causes of climate change).

Similar to Burke et al. (2018) and Chalupka et al. (2020) also recommend the use of community design, whereby community members are taught certain skills so that they can sustainably provide such services (e.g., psychological first aid training).

Researchers: Suggestions for future research

With the little empirical evidence that was gathered in this scoping review, it is to no surprise that a variety of future routes of research were proposed. Burke et al. (2018) suggest two practice-focused areas. Firstly, future research could examine and develop ways to build resilience in children in the face of climate change. Secondly, future studies could determine ways of encouraging children to have positive images of an attainable zero or low carbon future, as well as investigating how these images can promote mental wellbeing and healthy coping, then determining how adults can promote these ways of coping. The need for the expansion of research on the psychological effects of climate change on children to "non-developed," non-Western, low- and middle-class countries is also encouraged.

Ojala (2012a,b) brings up the need for certain variables and factors to be more closely considered. For instance, they mention that age needs to be investigated in a more specific manner (e.g., are these findings specific to 12-year-olds or are they found in other age groups as well?). They also acknowledge the importance that future studies examine context more closely when researching coping. Lastly, Strife (2012) presents two potential topics that can be used in future research, namely the effects of environmental concern on immediate environmental behavior, as well as the effects of children's concerns and feelings on long-term environmental behavior.

Discussion

The present scoping review included 18 articles that discussed the presence of vicarious reactions to climate change in children. The aim of this study was to explore the terminology used to describe eco-anxiety, to look at the evidence of eco-anxiety in children, and to identify the knowledge gaps and considerations for future research in this research topic.

Terminology used

The present results highlight an irregularity in the terminology used to describe children's emotional reaction to the awareness of climate change. Very few articles used the term eco-anxiety (16%), and those that did had different definitions of it; although, worry was a commonality amongst them. Other terms were also used to describe a fear and worry of environmental consequences in children including ecophobia, climate anxiety, environmental grief, and eco-despair. This lack of clarity is consistent with previous literature that finds that there are many different terms used that overlap in their definition, suggesting a need to be further investigated (Coffey et al., 2021). This variability of terms observed in the literature is representative of a developing area of research and a complex situation that is still being defined (Pihkala, 2020). Nonetheless, the most common word found in 14 of the articles was worry. The present review tends to confirm that, in children, eco-anxiety seems to manifest itself as many different emotions, not only fear, as the APA definition would suggest (see Clayton et al., 2017). Finally, none of the selected articles focused on a child-specific definition of eco-anxiety, rather applying those that emerged from literature in adults. Future research could aim to evaluate if eco-anxiety should be conceived and/or defined in the same way in children and adults alike. This is particularly important because applying an adult-centric definition to children may impose emotions on them and fail to acknowledge their reality. For example, research on anxiety disorders has demonstrated that the clinical manifestations of anxiety in children are different than in adults, and this could be the case with eco-anxiety (Beesdo et al., 2009)). Given that the definition is closely linked to the symptoms of anxiety, it is essential that care is taken to adequately explore these experiences to guide a definition that closely resembles children's reality. Initial evidence seems to suggest that children express a range of emotions that are often related to objects or people (Strife, 2012), whereas adults experience may be more existential in nature (Pihkala, 2020).

Evidence of eco-anxiety in children

Variability was also observed in the emotions related to the awareness of climate change, including fear, anger, hopelessness, worry, hope, and sadness. These emotions could potentially constitute different expressions of eco-anxiety in children, as it has been seen in adults (Arcanjo, 2019). However, some authors found that eco-anger, eco-anxiety, and eco-depression in adults were all related but different constructs (Stanley et al., 2021). It can be hypothesized that this would be the case in children, but none of the articles from the current review had a child- or youth-specific measure of eco-anxiety, rather they measured worry or climate-related emotions.

Our results support that eco-anxiety, and its variations, don't constitute a pathological problem. However, the included articles did not explore the association between anxiety or depressive disorders and eco-anxiety, which constitutes

an important gap in knowledge. Nonetheless, many of the authors mention that these emotions should not be considered pathological (Ojala, 2012a; Strife, 2012; Hickman et al., 2021). Authors Doherty et al. (2017) explained that, in adults, potential pathology associated with eco-anxiety is very context-dependent and case specific, so eco-anxiety should not be considered as a psychological problem from the outset. These same conclusions are found in the results of the present review, where eco-anxiety and eco-emotions may be positive reactions, in that they may lead to action. This could also lend support to the spectrum hypothesis of eco-anxiety, where on the one hand, children who experience strong emotions and who cope in a positive manner may be more hopeful and act (Ojala, 2012a; Burke et al., 2018; Taylor and Murray, 2020). On the other hand, some children may be overwhelmed by these feelings, and lack the tools to properly cope, leading to potential paralysis, learned hopelessness, and denial (Nagel, 2005). This spectrum interpretation of eco-anxiety should be further investigated and adapted to children and their specific contexts.

The vulnerability factors found in the present review are consistent with the growing body of literature that indicates that young people, indigenous groups, and people who feel connected to nature are particularly vulnerable to experiencing eco-anxiety and particular mitigation measures should be put into place to protect these groups from experiencing further trauma (Coffey et al., 2021). These vulnerability factors should be taken in account when further investigating the phenomenon of eco-anxiety in children as well as in education contexts.

Interestingly, the present scoping review revealed that girls were both more likely to feel worried and hopeful regarding climate change. This is concordant with previous research that reveals that girls are at higher risk of feeling internalizing symptoms, which include feeling sad, anxious, nervous, irritable, and depressed (Merrell and Dobmeyer, 1996; Bor et al., 2014). However, this may occur because girls generally develop higher levels of emotional awareness (Eastabrook et al., 2014), which would explain why they would also report higher levels of hope. Research with adults also confirm the women tend to have higher levels of climate change related worry (Heeren et al., 2021) and that this is potentially mediated by risk perception (Xiao and McCright, 2012). These gender differences warrant to be further investigated as there is also research finding no gender differences in worry (Clayton and Karazsia, 2020) and that gender is often measured in a binary manner.

Considerations and future research

Interestingly, many recommendations for specific social agents in children's lives surrounding the topic of eco-anxiety emerged; however, the novelty of the field and the need for more rigorous methodologies commends the importance of further research. Nonetheless, these preliminary considerations are important to guide researchers, parents, teachers and educators, mental health professionals, and people of power who have concerns about supporting children in the context of the climate crisis.

Parents

It is important for parents to acknowledge that their children will be learning about climate change through school, the media, and the internet, so their role is to maintain an open discussion with their children and adolescents, creating a safe space to discuss feelings and emotions about the issue (Strife, 2012). Books may be an excellent means of initiating conversations and tackling the issue of climate change with age-appropriate material (Boggs et al., 2016). Local bookstores can be helpful in identifying these books. Furthermore, the available scientific literature indicates that children imitate their parents' environmental behaviors and take on their values (Zerinou et al., 2020). Thus, it is important that parents be aware of their role as models to encourage environmental action that can provide solace for children who may be particularly concerned about climate change. An important gap in research exists in how parents' reactions and behaviors may affect how their children cope with climate change. For example, to what extent does having a parent who experiences eco-anxiety affect a child's emotional response to climate change? Future research should focus on the specific experiences of families that vicariously experience climate change.

Teachers and educators

Results from this scoping review indicate that teachers and educators should first teach their students environmental behaviors before introducing them to the facts about climate change (Sobel, 2007). Indeed, if children already have the tools to feel agency in the face of climate change, when they start learning about it, they may not feel hopeless and distressed. However, caution is warranted in excessively using action as an "antidote to eco-anxiety," as it can lead to burnouts or an unproportionate importance of individual action over collective, governmental, and large polluters' action (Pihkala, 2020). A significant research gap exists in how to avoid this type of reaction in children. Classrooms should also provide opportunities for students to normalize their emotions of guilt, sadness, or anger through group discussions (Plautz, 2020). Similar to what Ojala (2012a) has suggested, other authors support the importance of building resilience to cope with climate change, for example reframing the problem of climate change by highlighting the positive opportunities, fostering meaning-focused coping (Baudon and Jachens, 2021). Finally, teachers should also empower their students and teach them critical thinking skills, for example, to recognize reliable information (Nagel, 2005). For instance, philosophy for children workshops could provide a space for

children to discuss the issue of climate change while enabling them to think by and for themselves (Birch, 2020). However, teachers and educators may not feel like they have the adequate tools to put these into practice, so it is important that future research focuses on the needs of instructors to provide them with accessible tools to support their practice and their students. A few researchers have suggested ideas to support a change in education systems to integrate notions of collective actions moving away from simple climate change literacy (for example, González-Gaudiano and Meira-Cartea, 2019), but these new educational practices should also be further investigated in different contexts.

Mental health professionals

Very little indications arise for mental health professionals specifically, although some of the aforementioned suggestions may be applicable in a clinical context. Literature indicates that psychology can contribute to policies, prepare communities for the impacts of climate change, and individually help their clients cope with the potential distress (Berry, 2009; Baudon and Jachens, 2021). However, future research is required to identify potential interventions to help children develop coping mechanisms to deal with the awareness of climate change, and child or youth-specific mental health interventions to reduce eco-anxiety when there is. Furthermore, psychologists and mental health workers may benefits from training to specifically help clients who are experiencing distressing eco-anxiety (Swim et al., 2011; Pinsky et al., 2020).

School systems

Climate education and specific programs should be implemented in schools that also support children and youth's mental health (Pinto and Grove-White, 2020). Authors included in this review also suggest introducing climate education at the beginning of elementary school, including attainable actions per grade, and incorporating exposure to nature (Sobel, 2007; Pinto and Grove-White, 2020). This component of nature was not further explored in any of the selected articles; although, child exposure to nature could predict adult environmental attitudes and behavior, and nature-based therapies have been beneficial to help adults with their eco-anxiety (Asah et al., 2018; Baudon and Jachens, 2021). Given that nature exposure could help adults reduce their depressive symptoms (Watkins-Martin et al., 2021), future school-based programs should explore the benefits of integrating an outdoor component that could enhance children and youth's connection to nature (Collado and Corraliza, 2015; Malboeuf-Hurtubise et al., 2022). However, it will be important that upcoming research compare the effects of the different school programs to understand what strategies work best, and especially how these could support children and youth mental health as they learn about the consequences of climate change.

Adults and people of power

It is recommended that people who are in power acknowledge their responsibility in the climate crisis (Hickman et al., 2021; Pickard, 2021). Taking off the burden of the duty to mitigate climate change that has been put on the shoulders of youth and children and showing them that greater action is being taken by governments can potentially reduce the distress felt by this generation (Hickman et al., 2021), although this remains to be further investigated. Adults in general need to be accountable and act in accordance, to show young people they are stepping up and caring for the planet (Ojala, 2013; Plautz, 2020). Furthermore, children and youth should be consulted in decision-making and further encouraged to have a voice in community affairs; however, the ways in which to do this successfully should be further investigated (Vogiatzi et al., 2017).

Macro level: General population

Communities also have the responsibility to protect children and youth's mental health by preparing for potential environmental disasters (i.e., floods, fires, etc.) (Burke et al., 2018). It is important that more vulnerable communities, because of their geographic location or socioeconomic status, be especially supported in the development of different approaches to support mental health. Indeed, building resilience to climate change may be essential, but little literature exists on how this may be achieved and how to tailor such preventive strategies to different communities around the world (Chen et al., 2020).

General gaps in research

The current review only identified studies employing research designs that were descriptive in nature, indicating a gap in empirically based data using rigorous methodological designs. Indeed, future research could move toward inferential designs to explore the causality between certain variables associated to eco-anxiety in children, such as coping mechanisms, emotional resilience, and general knowledge about climate change, to name a few.

In general, research on eco-anxiety seems to be moving much slower than the public discourse on the topic (Pihkala, 2020), especially when it comes to children. This review puts to light the importance of better defining the concept of eco-anxiety in children, using research methods that could give children and youth a voice in their experience, as suggested by Strife (2012). Furthermore, gaps exist in the specific experience of children and youth who are already living with a mental health problem, and how they are specifically affected by the awareness of climate change.

Hickman et al. (2021) suggest that "A complete understanding of climate anxiety in children and young people must encompass relational, psychosocial, cultural, ethical, legal, and political factors" (p. 9).

Strengths and limitations

This scoping review presents multiple strengths. First, this review follows the strict methodological guidelines suggested by Levac et al. (2010) and Tricco et al. (2018) for conducting rigorous scoping reviews. Some limitations are inherent to scoping reviews, such as providing breadth rather than depth of knowledge in the subject (Tricco et al., 2018). This can be specifically seen in the multiple databases searched. However, given that the topic of eco-anxiety is interdisciplinary, emerging, and that the concept in children warranted to be clarified, this method was appropriate. Nonetheless, we suggest that, as research on eco-anxiety continues to emerge, future studies should go in depth into the articles and evaluate the quality of these. Furthermore, to our knowledge, only one other scoping review (Martin et al., 2021) was published on the topic of eco-anxiety in children, thus our work helps in laying the groundwork for future research and questions on this important topic.

In terms of limitations, both reviewers responsible for evaluating the relevance and summarizing sources included in this scoping review had a psychology background. However, great care was taken to be aware of potential biases and remaining neutral in the inclusion of the articles. Furthermore, no books, nor literature in other languages that English were included (no relevant French material was found), leading to potentially important data to be missed.

Finally, we acknowledge that an important, yet still small, body of literature that focuses on the experience of indigenous communities' experiences of climate change was not included in the present review given that the articles found did not focus on children's experiences. This decision was also made because these communities often already experience the direct and indirect effects of climate change, so vicarious mental health effects seem less present (or, at least, less documented in the available literature). Nonetheless, indigenous communities have unique challenges that should not be ignored in this line of research (please see Hunter, 2009; Cunsolo et al., 2013; MacKay et al., 2020; Middleton et al., 2020).

Conclusion

This scoping review highlighted the presence of eco-anxiety in children and youth. Indeed, this population experiences a variety of emotions such as anger, sadness, guilt, and hopelessness that characterize eco-anxiety. However, none of the included articles had child-specific measures of this concept, suggesting that future research should further investigate the phenomenon from a child-specific perspective. This review also underlines the important roles of parents, teachers/educators, mental health professionals, school systems, and adults and people of power to mitigate the effects of climate change on children and youth's mental health. Although the identified research lays the groundwork for the topic of eco-anxiety in children, many research gaps are highlighted as future directions for research.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

Conceptualization: TL-G. Methodology, formal analysis, and writing–original draft of manuscript: TL-G and TM. Writing–review and editing: CM-H, MG, and P-OP. Supervision: CM-H and CC. All authors have read and agreed to the published version of this manuscript.

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Contribution to the field statement

Given the limited research on eco-anxiety and youth, this scoping review lays the groundwork for future research directions on this topic. Specifically, it helps identify key elements from what is currently known in the literature, such as the importance of promoting hope to enable action. Furthermore, it identifies the research gaps and raises important research questions, including how to help youth cope with eco-anxiety. This review can inform the work of policymakers, activists and mental health workers who undoubtedly will be called upon to find solutions for the kids living with eco-anxiety.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix

Appendix A: Search strategy example

Step 1: An initial limited search was done in APA PsycInfo on March 4th, 2021

Step 2: Keywords for each key concepts included:

BOX 1

Search Term #1: ABSTRACT(Child* OR Kid OR Adolescen* OR Youth OR Teen* OR Preschool* OR Kindergarten* OR School-aged OR Elementary OR School OR parent* OR famil*)

AND

BOX 2

Search Term #2: ABSTRACT("Global warming" OR "Climate change" OR "Ecological crisis" OR "Climate disaster" OR "Environmental disaster" OR "Environmental problems" OR "climate crisis" OR "environmental melancholia" OR "ecological disaster" OR "Environmental Issues")

AND

BOX 3

Search Term #3: ABSTRACT("Eco-anxiety" OR Ecoanxiety OR solastalgia OR "ecological worry*" OR Angst OR "Mental health" OR Anxiety OR Depression OR Hope* OR Anticipatory OR Despair OR Optimism OR Engagement OR Emotions OR Grief OR Ecophobia OR attitudes OR "Psychological effects" OR worry OR resilience OR "eco-psychology" OR "eco-angst" OR "eco-guilt" OR "eco-paralysis" OR "environmental concern" OR "climate activism")

This initial search yielded 284 articles.

Appendix B: Scoping review protocol

Review title: Eco-anxiety in Children: A scoping Review of the Mental Health Impacts of the Awareness of Climate Change

Review question: What is the nature of the evidence on eco-anxiety in youth and children?

Inclusion criteria (PCC):

Population– Children (under 18 years of age)

Concept–Eco-anxiety: "a general term for difficult feelings because of the ecological crisis"

Context–Climate change

Exclusion criteria:

Studies that only included mental health impacts of climate related events (e.g., after a hurricane) were not included.

Only material in English and in French were examined due to the language capacity of the reviewers.

Study details and characteristics extraction:

Initial data chart

Author(s), title, year
Country
Study design, participants
Age mentioned
Study aims, measures, main impacts
Definition of eco-anxiety or related concept, other terminology used
Impact of eco-anxiety on children
Vulnerability and protective factors
Author recommendations

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A goal-framing perspective on the important aspects of energy-efficient multifamily buildings

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The growth of Sweden's urban population necessitates new approaches for increasing the sustainability and energy efficiency of multifamily buildings. The development of such approaches will require a holistic and integrated understanding of the factors driving the decision making of both professionals who design buildings and end-users who live in them. This paper, therefore, uses the goal framing theory to determine which aspects of multifamily buildings are considered important by these two groups of actors. An empirical study based on semi-structured interviews with professionals involved in building design and development (project developers, housing company representatives, architects, and engineers; $N=15$) was conducted to identify goals affecting the choices made during building design and development. In parallel, a questionnaire survey of building end-users ($N=61$) was conducted to determine which factors guided their choice of dwelling. It was found that professionals' design choices were primarily governed by normative goals relating to environmental benefits but were also influenced by the other goals. These included gain goals relating to budgetary constraints and keeping the building's operational and maintenance costs low. Hedonic goals were also important; some design choices were made with the aim of providing pleasant, comfortable, and convenient living environments, or of giving the buildings a distinct aesthetic or some other special features. By comparing the professionals' responses to the end-user surveys, it was found that the two groups had similar views concerning gain goals; both considered it important for apartments to be affordable and easy to maintain. However, their views on hedonic and normative goals differed markedly. The professionals sought to strike an optimal balance between different related aspects, whereas end-users placed greater importance on aspects relating to hedonic and gain goals when choosing dwellings. The findings provide a basis for constructive discussions on building design and development, and the scope for creating buildings that encourage end-users to adopt sustainable living practices while also satisfying their needs and preferences.

KEYWORDS

building end-user, design choice, dwelling choice, energy efficiency, goal-framing theory, multifamily building, professional

Introduction

The growth of Sweden's urban population means that there is a need for new ways of increasing energy efficiency in multifamily buildings, where space heating and domestic hot water account for a large proportion of the total energy use (Savvidou and Nykvist, 2020). Although efforts in this direction have been made by introducing new building regulations, new design strategies, and smart technologies, energy use in buildings has not declined significantly over the past two decades (the Swedish Energy Agency, 2019).

A combination of improvements in design and technology together with changes in the behavior of building end-users could substantially reduce energy use (Schweiker and Shukuya, 2010). It has been suggested that buildings could convey information about energy and behaviors through their design, form and energy-related features (Brown et al., 2009), and that green or sustainable building design could potentially foster pro-environmental attitudes and behaviors among users (Tucker and Izadpanahi, 2017). Moreover, the physical environment can have a "nudging" effect on energy-efficient behaviors, meaning that making changes in the physical environment can shape and encourage people within that environment to act in ways that increase energy efficiency (Lehner et al., 2016). Although it has become increasingly common to apply various energy-efficient solutions to both new and old multifamily building projects, previous studies have found that such solutions are typically considered optional (Storbjörk et al., 2018) or fail to challenge end-users' energy-related behavior (Hagbert and Femenias, 2016). Failures to challenge end-user behavior were explained in terms of the fact that energy-efficient buildings were generally designed and built based on normative assumptions about housing standards and the comfort and convenience of end-users. A separate study showed that technical details rather than end-user behavior were the main focus of discussion among professionals involved in renovation processes (Palm and Reindl, 2016).

There is also the question of whether buildings with good energy performance can be considered sustainable if their users dislike them. For instance, an energy-efficient building envelope can substantially reduce energy consumption for heating but may also create problems in the indoor environment such as uncomfortably high indoor temperatures, leading to high cooling demands in summer (Tettey and Gustavsson, 2020). Energy-efficient technologies and appliances can even cause rebound effects that increase energy use in buildings (Alam et al., 2017). This may be due to user behavior changes, particularly if users believe that because the building is equipped with energy-efficient technologies or appliances, there is no need to think much about energy savings. A study on lighting controls (Maleetipwan-Mattsson, 2015) found that introducing automatic controls to switch-off lights can encourage habitual failure to manually switch lights off regardless of the availability of manual controls. The findings highlight the importance of integrated knowledge among building professionals and building users in the design and development of sustainable residential buildings (Janda, 2011; Hagbert and Femenias, 2016). It is also important to understand the expected performance of the buildings from both professionals' and users' perspectives in order to maximize energy savings.

Studies on professional perspectives (Zalejska-Jonsson et al., 2012; Hagbert and Femenias, 2016; Isaksson and Linderoth, 2018; Sandberg, 2018; Storbjörk et al., 2018) have highlighted several factors that are important in the design and implementation of energy-efficient multifamily buildings, including cost and financing considerations, norms relating to housing and material living standards, and knowledge about the benefits of addressing environmental considerations. However, it is still unclear whether the buildings can be expected to create opportunities for residents to adopt sustainable behaviors (Storbjörk et al., 2018). It was found that the most important issues for individuals looking to buy or rent an apartment were the apartment's size, design, and location; energy and environmental factors had only a minor impact (Zalejska-Jonsson, 2013). A slight majority (56%) of individuals owning green apartments considered environmental certifications to be important and to therefore potentially influence a building's attractiveness. A significantly lower proportion of owners of conventional apartments (39%) expressed similar sentiments. Among apartment renters, 40% of those renting green apartments considered energy and environmental factors to be important. There was no significant difference of opinion between individuals renting green apartments and those renting conventional apartments. The views of building end-users were broadly consistent with those of construction professionals relating to building norms.

Previous research on the perspectives of professionals and building end-users has focused on energy and environmental factors; other factors such as overall satisfaction and social environment have received less attention. More comparative studies are, therefore, needed to better understand the perspectives of these different actors and determine how well they are aligned. The results of such studies would provide a basis for constructive discussion about the energy efficiency of residential buildings from an integrated perspective and could thereby shape creative building design and development processes that support sustainable living and lifestyles. This paper presents an empirical study that was part of a research project investigating the design-building-user relation from the perspectives of professionals (building developers, architects, and engineers) and building end-users. Specifically, the paper aims to determine which aspects of modern energy-efficient multifamily buildings are considered important by professionals and building end-users. A theory-based approach rooted in goal framing theory (Lindenberg and Steg, 2007, 2013; Steg et al., 2014) is used to identify considerations that guide (i) professionals when making design choices about buildings and (ii) building end-users when choosing their dwellings, and to compare the views of these two groups. It was expected that the theoretical framework would clarify the important aspects of the buildings and make it possible to view the

issue from an integrated perspective that accounts for the positions of both groups of actors.

Goal framing theory

According to Lindenberg and Steg (2007), goal framing theory treats goals as the main determinants of how individuals perceive a given situation, process information, and act in response. Goals principally govern how individuals evaluate different aspects of a situation, what they focus on, and what alternatives are considered. Behavioral outcomes are usually influenced by multiple goals but may be primarily governed by just one.

Goal framing theory has been used to understand environmentally relevant behavior in specific situations including the adoption/rejection of energy-efficient solutions (Johansson et al., 2015; Gerdhardsson et al., 2018; Hameed and Khan, 2020). It posits that behavior is guided by three goal frames: (i) a hedonic goal frame associated with an individual's desire to improve the way they feel (e.g., by seeking pleasure, excitement, or greater self-esteem) while avoiding negative thoughts or effort, (ii) a gain goal frame associated with the desire to gain (or avoid losing) resources such as time or money, and (iii) a normative goal frame associated with the desire to follow social norms (e.g., by contributing to energy reduction, combating climate change, or caring for others). These goal frames have been linked to a sustainable energy technology acceptance framework (Huijts et al., 2012) that proposes that acceptance/rejection of new technologies is based on the individuals' evaluations of benefits, costs, risks and effects on the society or environment, and the resulting negative or positive feelings about the technologies. In any given situation, one of the three goal frames (the so-called "focal goal") will have the strongest influence on an individual's cognitive and motivational processes, and thus on their behavior (Lindenberg and Steg, 2013). Individuals make choices based on costs, risks or benefits when a gain goal is focal. If a normative goal is focal, decisions are based on effects on the environment or society, while feelings are the main determinant of decisions when a hedonic goal is focal. The degree to which a focal goal influences behavior is affected by other goals, its dominance is strengthened if it is compatible with other goals and reduced if there are conflicts with other goals (Steg et al., 2014).

A study on purchases of energy-saving air conditioners (Hameed and Khan, 2020) found that normative goals strongly influenced consumers' intention to purchase the products, and that this effect was strengthened by hedonic goals. In this case, the influence of hedonic goals correlated with that of gain goals but had no significant effect on behavior. Hedonic goals of feeling good and normative goals of feeling obligated to act pro-environmentally were found to guide residents' lighting choices at home, whereas gain goals of saving money were found to have little impact (Gerdhardsson et al., 2018). In a study on outdoor lighting choices, Johansson et al. (2015) found that a housing association's decision to reject new energy-efficient outdoor lighting in a Swedish housing cooperative was driven by multiple goals. Among the association's board members, the normative goal of perceived safety for elderly residents was weighted against the gain goals of avoiding costs and reducing energy consumption and therefore became the focal goal; the hedonic goal of improving perceived lighting quality seemed to have little influence. In contrast, the residents of the buildings were motivated primarily by the normative goal of improving perceived safety. Besides providing insight into the goals that governed the acceptance/rejection of the energy-efficient lighting, this study showed that goal framing theory could be used to compare the goal frames of actors who made the decision about the lighting technology (the board members) to those of its end-users (the residents).

To the authors' knowledge, goal framing theory has not previously been applied to the different groups of actors whose choices influence the energy efficiency of multifamily buildings. Real-world studies adopting this approach could thus provide new insights from an integrated perspective and reveal features of energy-efficient multifamily buildings that promote their acceptance by both building design professionals and end-users.

Objective

This paper's objective is to provide insights into the goals that determine how different aspects of energy-efficient multifamily buildings are evaluated by professionals involved in building design and development and by the buildings' end-users. Specifically, the paper seeks to identify the focal goals of both groups and to determine how they relate to other goals. The research questions addressed are:

- What goals influence professionals' choices in building design and how are they related?
- What goals influence end-users' dwelling choices and how are they related?
- To what extent are the goals important to building end-users aligned with those important to professionals?

Materials and methods

The empirical study is based on semi-structured interviews with professionals involved in the design and development of residential buildings (including project developers, housing company representatives, architects, and engineers) and a questionnaire survey distributed to a group of building end-users (residents).

The interview questions (see "Procedure") were designed to collect information on design choices which were considered and selected by professionals having different roles in the design and development of multifamily buildings, and drivers

of the choices. Based on to Cockton's (2013) work, a design choice was considered as a solution to a problem through features and qualities of the built environment and also, as a concept. These different forms of design choices were taken into account and addressed through different interview questions. Further, the interview questions were reviewed by a colleague with experience in the building industry to check whether the words used to express design choices are commonly used in the field.

The questionnaire survey (see "Procedure") was used to collect information on how residents weight different aspects of their dwelling choices in relation to the goal frames. This approach was applied since it was not possible to conduct interviews with a relatively large number of residents within the framework of the project. The questionnaire items were developed based on the respective goals' related aspects addressed by previous studies on the rejection/adoption of energy-efficient solutions (Johansson et al., 2015; Hameed and Khan, 2020). Two aspects were selected for each distinct goal frame to describe drivers of dwelling choice. Different aspects used in the previous studies on the roles of goal frames in the rejection/adoption of energy-efficient solutions were taken as a starting point.

Interviews with professionals

Fourteen semi-structured interviews were conducted with 15 professionals involved in the design and development of multifamily buildings: 5 project developers or housing company representatives, 5 architects, and 5 energy engineers (two interviewees: an architect and engineer, participated in one interview together) who collectively worked for nine different companies including architectural, consultancy, construction, and municipal companies. Participants invited to participate in the interviews were identified as different actors playing diverse roles in the design and development of the buildings to achieve energy efficiency. Participants were recruited through the network at the University's Department of Architecture and Built Environment and *via* referrals from the previous interviewees. They were initially contacted by sending an email invitation containing a document explaining the study's background, aims, and procedure as well as the voluntary nature of participation, the applied data confidentiality procedures, and the study's compliance with the EU's general data protection regulations.

The interview participants (11 males and 4 females) had worked in the fields of housing development, building construction, or architecture in Sweden for at least 5 years, and some had worked in the field for more than 30 years. Their areas of expertise included housing design, sustainable building design, life cycle analysis, energy-efficient and environmental building design, building performance simulation, environmental certification systems, project management, building management and social sustainability issues.

Procedure

Interviews were conducted between March 2020 and September 2021. Before being interviewed, each participant gave informed consent to their participation and agreed that the interviews could be audio recorded. One participant refused to allow the interview to be recorded, so written notes were taken during the interview instead. The interviews were conducted online using video conferencing software.

Participants were first asked to summarize their background using questions such as *"Could you briefly tell me about your work?"* and "*How long have you been working in the field?*." To capture design choices which have been applied to multifamily buildings, they were then asked to describe their views on the design and development of the buildings, with particular emphasis on the aspects and design principles that they consider most important. Typical questions asked during this phase of the interview were "*Could you describe your view on the development of energy-efficient housing in Sweden?," "In your opinion, what are the most important aspects of today energy-efficient multifamily buildings?,"* and *"What do you regard as key design principles when working on energy-efficient multifamily buildings?"* To further explore specific design choices, the participants were next asked to describe the solutions they used to achieve energy efficiency using questions such as "*Could you tell me more about the solutions you have applied to achieve energy efficiency?"* Finally, they were asked about how they account for the role of building end-users during the processes, using questions like *"Do you consider the buildings' occupants when working on energy-efficient multifamily buildings?"* and *"In what ways are the behaviors of building occupants accounted for when working on the buildings?"* The interviews lasted for between 40 min and 1 h.

Analysis

The recordings were transcribed by PM. The textual material was carefully read and analyzed using a deductive thematic approach (Braun and Clarke, 2006) to allow the mapping of goal framing theory onto the participants' statements about the design and development of energy-efficient multifamily buildings and addressing the desires and behaviors of the buildings' end users. In such processes, design choices were regarded as key concepts or design principles and solutions (including both design and technical solutions) that the interviewees had applied to the buildings.

The data were coded manually, and every statement pertaining to design choices made during building design and development was coded based on its alignment with the three core constructs of goal-framing theory, namely hedonic goals (related to feelings about the design choices in relation to user perceptions of living environments), gain goals (related to cost–benefit analysis and resource-and/or time-saving), and normative goals (relating to effects on the environment or society in the forms of environmental and social benefits). These goals have also been considered in relation to a sustainable energy technology framework (Huijts et al., 2012).

If a statement aligned with multiple goals, it was coded under each one. To assess interrater agreement, selected statements from the transcripts were coded by the two authors in parallel and then compared to see if they were mapped to the same goals. This process indicated an initial interrater agreement of 93%, with 100% agreement after discussion between the two authors. The codes were then analyzed to identify patterns in the ways participants expressed their perspectives in relation to each goal frame and the relationships between the goal frames.

Questionnaire survey among building end-users

Procedure

The survey was conducted between 2021 and the beginning of 2022; it was part of post-occupancy evaluation (POE) of four newly built energy-efficient or green-rated multifamily buildings. The main objective of POE was to investigate how building-end users experience and use the buildings in relation to energy use. The POE contained about 15 questions and 41 items. To keep the survey to a reasonable length, the number of items corresponding to different aspects of dwelling choices were limited. Questionnaires were sent out by mail to residents of the buildings together with a cover letter and return envelope. The residents' names and addresses were retrieved from a public online database. A total of 319 residents received questionnaires and invitations to participate in the study (excluding undelivered mail) and 61 questionnaires were completed and returned, giving a response rate of 19.12%. The respondents included 27 males, 32 females, and 2 nonbinary individuals. Their ages ranged from 23 to 91 years, and their mean age was 53.48 years (SD = 17.83).

The residents' evaluations of different aspects of their dwelling choice with respect to the goal frames were assessed using the question "*How important are the following issues when you chose your dwellings*?" The question was answered by assigning scores to the following six items, each of which corresponds to a distinct goal frame:

1. The building has a distinct style and character (a hedonic goal, i.e., seeking pleasure or interest).
2. The apartment has amenities that I appreciate (a hedonic goal, i.e., seeking pleasance, comfort, or convenience).
3. The apartment is affordable (a gain goal, i.e., minimizing a cost).
4. Maintaining the apartment is easy and requires little effort on my part (a gain goal, i.e., saving time and money).
5. The building is certified as an environmental building or equivalent (a normative goal, i.e., contributing to environmental sustainability).
6. The building has good common areas such as a laundry room and a bicycle room that can be used by all residents (a normative goal, i.e., relating to social benefits).

Participants rated the importance of these items on a five-point rating scale where 1 corresponds to "very unimportant" and 5 to "very important."

Data analysis

Data were missing for item 2 (the apartment has amenities that I appreciate; missing data in 1.64% of responses) and item 3 (the apartment is affordable; missing data in 1.64% of responses). Since the data were not satisfactorily normally distributed (the p value obtained in the Shapiro–Wilk test was < 0.001) for all items, the non-parametric Kruskal–Wallis test and the Mann–Whitney U-test with the Bonferroni correction (giving a stricter alpha level of $0.05/6 = 0.008$) were used to investigate the extent to which each goal drove the respondents' choice of dwelling. In addition, a correlation analysis based on Spearman's Rho (applying the exclude cases pairwise option) was performed to examine associations between the items associated with each goal. All statistical analyses were performed using IBM SPSS Statistics 28.

Findings

Results obtained from the interviews with the professionals and the questionnaire survey of building end-users are first presented separately. Their results are then discussed jointly to determine whether and to what extent the perspectives of the professionals overlap with those of the end users.

Goal frames guiding design choices

The results of the deductive thematic analysis are presented below. The frequency with which the participants' statements pertaining to design choices tallied with each core construct of goal framing theory is presented in Figure 1.

Hedonic goal frame

The hedonic goal frame was based on feelings about design choices that were expressed during the interviews when discussing how the buildings' end-users would perceive the living environments that the buildings offered. The issue most frequently mentioned as being important by professionals, particularly architects, and project developers or housing company representatives, was the perceived pleasantness of the dwellings, which was evaluated based on factors such as access to daylight, views, and noise levels. Other important hedonic aspects were the appearance and design features of the buildings' exterior and interior, convenience, a good standard of living, and a comfortable indoor environment or climate. The latter factor was further characterized by a comfortable temperature, adequate ventilation humidity control, access to daylight, good acoustics, and a lack of harmful emissions from building materials. These aspects were frequently mentioned in relation to both common or shared areas and apartments.

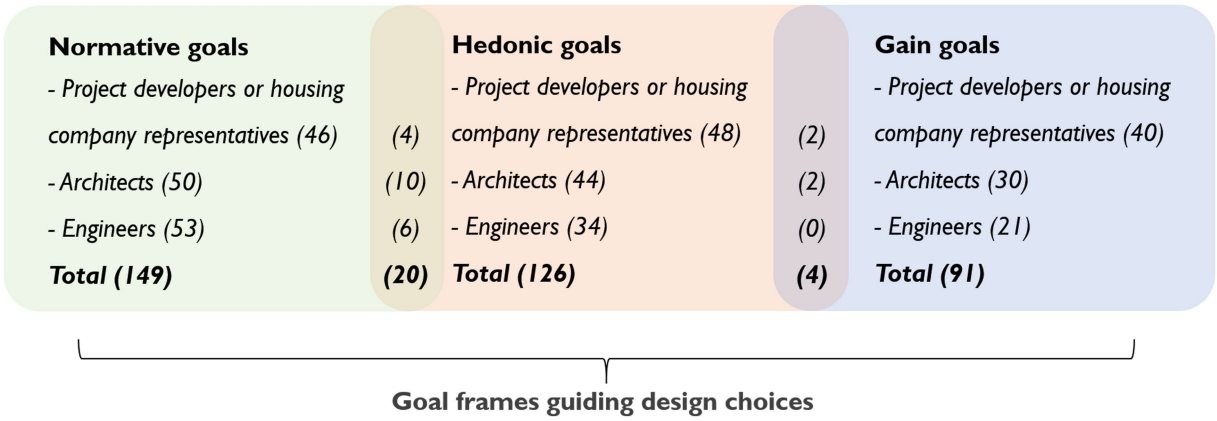

FIGURE 1
Numerical information indicates the frequency with which the participants expressed the goals. Note: overlaps were identified between hedonic and normative goals, and between hedonic and gain goals.

> *"The common laundry is on the first floor and have big windows…. We make the laundry room very inviting. It is nice and it feels pleasant to be in. If all machines are unoccupied, you can book up to six machines at the same time."* (Housing company representative).

> *"There are attempts to make apartments function well by considering how people use windows. I always try to provide space for a baby's cot in the bedroom even it is 'not a must'. I also try to create spaces that are controllable (by the building end-users) so people can sleep well and close the windows. (I) work to make sure people will feel good when they enter the apartment. I also try to make the kitchen feel as professional and usable as possible."* (Architect).

These quotes show that positive feelings about design choices were associated with expectations concerning building end-users' perceptions of the living environments' pleasantness and convenience. Two participants (one architect, one engineer) also mentioned the need for privacy in this context, and took this need into account when making design choices.

> *"We (architects) need to understand that 'your dwelling' is an automated place where you can be however you want to be. /…./. One person may want to have a lot of friends in their home and another may not want to host friends, and I think that being able to make that choice is a human right. So I could see kind of limit where you as an architect should not try to regulate behavior too much in the dwellings you create. So ideally, we (i.e., all actors) should perhaps think that 'it is more about what we can share' which is the most important thing."* (Architect).

The quote above expressed a rather negative feeling about design choices intended to influence the behaviors of building-end users (and by extension, their privacy inside their apartments) while also placing greater focus on the buildings' shared areas. However, some design choices were seen as having the potential to promote energy efficiency without affecting privacy or the availability of features enhancing comfort and convenience in apartments. For example, one project developer expressed positive feelings about a solution that aimed to reduce water use by changing behavior.

> *"Individual measurement and charging means that tenants pay for the hot water or water that they use, and I think that's a great tool. It means that residents learn the cost of hot and cold water, which is normally included in the rent. /…./. It will be clear to the users and could influence their behavior when they receive a bill or rent demand. For example, they might say "oh, I should not bathe every day because each bath consumes 4–5 liters of hot water and costs a lot of money – I should shower instead."""* (Project developer).

Gain goal frame

Economic considerations played a significant role in the selection of design choices particularly for project developers or housing company representatives and architects. Participants mentioned the need to avoid excessive design and investment costs. In general, using high quality materials and smart technologies or solutions to reduce energy use increases investment costs, which was frequently cited as a barrier to efforts to increase energy efficiency in multifamily buildings. The professionals preferred to avoid the extra costs of smart technologies or solutions in order to keep apartment prices affordable, and design choices were made with the aim of minimizing construction costs and financial risk. One housing company representative noted that in one case, a choice made when designing a building had been re-evaluated during the

building's use phase and was found to have been ineffective in the long term.

> *"We measured and calculated that 30–35% of energy consumption was due to the central water system even though it was only used for a total of 10 min. Cold and warm water are so close, so I do not think the solution is good."* (Housing company representative).

Four participants (two architects, one engineer, one project developer) stated that maximizing a buildings' usability by ensuring that all of its functions are used has a positive impact on cost-effectiveness. If residents did not use the building's functions in accordance with the intended design, the implication was that some of the money invested into the building had been spent ineffectively. Moreover, long-term cost effectiveness was considered when making design choices. In addition to energy costs, which were mentioned by most participants, there was a recognition that financial gains could be realized by reducing overall operational and maintenance costs during the buildings' use phase.

> *"For me it is all about costs - whether it is energy, money, time, or materials, it does not matter. All of them have to be considered together because if I waste a lot of energy, that is not sustainable. If I have a great product that is super energy efficient but breaks every year and forces me to buy a new one, that's no good. So these things have to be considered."* (Project developer).

This quote shows that the participant recognized that design choices can influence operating and maintenance costs that may not benefit only the buildings' owners but the building-end users may also save time and costs for maintaining their own apartments.

Normative goal frame

In the context of this study, normative goals are goals pertaining to the environmental and social benefits of design choices. The chief environmental benefit was seen as reducing energy consumption and greenhouse gas emissions during the buildings' use phase. All participants, regardless of their precise role in the design and development of the buildings, stated that their design choices relating to these issues were primarily made to comply with building energy codes and standards together with building regulations and guidelines. Five participants (one architect, one engineer, and three project developers or housing company representatives) also mentioned that organizational visions and goals pertaining to environmental sustainability played important roles and prompted efforts to design buildings such that they would receive green or environmental certifications.

> *"Energy requirements always come from the National Board of Housing's requirements…. but our requirements are based on the criteria for the 'Environmental Building – Silver' certification." (Engineer).*

Participants believed that social benefits were realized through design choices that provide safe and secure living environments in accordance with building regulations while also promoting social inclusion and interaction between the building's end-users. A couple of participants (two architects and one housing company representative) discussed efforts to promote social inclusion in a housing project by providing different forms of tenure and to encourage social interaction in particular through the common areas.

> *"I have noticed that when we sit and talk about new housing projects that are going to be built, we talk a lot about common areas and reducing the size of the apartments to incorporate common areas where people can sit and work or do something and also meet and talk to their neighbors."* (Housing company representative).

Additionally, most participants (five architects, two engineers, and four project developers or housing company representatives) saw their work on the design and development of multifamily buildings as a way of addressing sustainability challenges and the United Nations sustainable development goals. Some participants further suggested that the sustainability challenges facing society need to be taken into account when considering what makes a multifamily building sustainable. This has affected norms in the building industry and has therefore influenced design choices.

> *"Over the last 10 years people have started talking about sustainability rather than energy saving, so the whole branch (of the firm) has begun looking at new practices, arguments, and requirements…."* (Housing company representative).

This quote shows that the design and development of multifamily buildings has moved beyond merely seeking improvements in energy use and is now focused on more holistic approaches for creating sustainable buildings. Participants also stressed the complexity of integrating the three dimensions of sustainability in practice.

In the participants' statements (Figure 1), overlaps of the goals were identified, mostly between the normative goal relating to social benefits and the hedonic goals relating to convenient, pleasant or attractive living environments (12) in making design choices for shared or common areas. There were also overlaps between the normative goal relating to environmental benefits and the hedonic goals relating to the convenience, pleasantness or attractiveness (2) and the indoor comfort (1) of apartments, and the appearance as well as design features of buildings (1). The gain goals relating to cost effectiveness and to low operation and maintenance costs were found to overlap with the hedonic goals relating to comfort and convenient living environments (4).

(Note: numerical information indicates the frequency with which the goals overlapped).

Relationships between goal frames and their influence on design choices

Overall, the interviews showed that the design choices made during the design and development of energy-efficient multifamily buildings were principally guided by normative goals relating to environmental benefits. This was reflected in statements about the need to comply with building energy codes and standards and to obtain green or environmental building certifications. Most efforts focused on reducing the energy used for space heating and domestic water heating. This was generally achieved by making design choices relating to the building's orientation, form, ecological features, the materials used in the façade (including doors, windows, and insulation), interior walls, and systems for heating, ventilation, cooling, and providing hot water. Moreover, efforts were made to reduce environmental impacts by using solar panels to generate electricity for use in the buildings' common areas and by installing energy-efficient lighting, equipment, appliances and fixtures. The behavior of building end-users was generally accounted for by performing energy calculations in which the expected number of users and their behaviors were quantified on the basis of reference values for variables such as occupancy hours, durations of window opening for airing, release of bodily heat, and consumption of domestic hot water and electricity. However, it was often noted that the values used in these calculations may not fully reflect reality. Normative goals relating to social benefits was also highlighted as drivers of design choices, particularly in relation to the buildings' common or shared areas. Key objectives in this regard included ensuring easy access, pleasantness, and attractiveness to promote social interaction among the building's end-users; such key objectives were associated with hedonic goals. Participants also emphasized the environmental benefits of the design of such areas (e.g., staircases, bike rooms, common laundry rooms, gardens, and trash rooms), which could potentially encourage energy-saving and environmentally friendly behaviors among building end-users.

The relationships between the goals and their influences on design choices are illustrated in Figure 2. Although the normative goal relating to environmental benefits was found to play a dominant role when making design choices, it appeared that multiple goals were interrelated. Several participants stated that design choices were made with the aim of staying within a 'reasonable' budget to keep the apartments affordable (gain goals) while achieving acceptable levels of energy efficiency (normative goal) and providing good living environments (hedonic goals) for the building's end-users. For example, one choice was made on economic grounds due to its long-term energy efficiency.

> *"Insulating buildings well enough to reach the most demanding (energy) requirements is very expensive, but going 0 to 100 m^2 of solar panels gives a much greater benefit." (Engineer).*

This quote clearly illustrates how the participant weighted different design choices from an economic perspective, leading to a preference for solar panels. Most participants similarly expressed positive feelings about this choice regardless of their roles. Among other benefits, the inclusion of solar panels was seen as something that could trigger interest or excitement among prospective residents while also making them aware of the environmental benefits realized through the building's capacity to generate its own energy. A couple of participants also described their awareness of the consequences of overproduction.

Further, the participants also felt that the normative goal relating to the environmental benefit sometimes created difficulties when trying to make design choices aligned with the hedonic goal of creating pleasant and attractive living environments.

> *"In our projects that we have struggled to provide enough daylight, which is something that has become increasingly important. /…./ some municipalities now require daylight calculations for building permits. When dealing with very dense blocks where buildings are closely packed, the only way we can increase daylight is by increasing window areas. However, to reduce heating requirements, we have to reduce window areas, so there is a conflict that cannot really be resolved."* (Engineer).

The quote above shows that the professionals were aware that the goal of minimizing energy demand for heating could impose limitations on the scope for maximizing the pleasantness of the living environment by providing good access to daylight. This was also seen as a new challenge relating to the normative goal frame because of the introduction of a requirement to perform daylight access calculations in order to obtain a building permit. The professionals also recognized that the need to comply with building energy codes (another normative goal) imposed constraints on the design and affected the buildings' esthetics (associated with a hedonic goal), necessitating a simple building form with a minimal façade area.

> *"There are lots of buildings with interesting forms in Europe and other places that we could not have here because of the need to comply with energy requirements, but I am so used to it (simple building forms) so I did not think about it."* (Engineer).

Furthermore, some choices that could enhance the hedonic goals of comfort or convenience in the apartments had to be avoided:

> *"We try to avoid using comfort floor heating in buildings because it causes very high energy consumption; it is almost impossible to include underfloor heating in low energy buildings."* (Engineer).

> *"Sometimes we do not even include dish washers - we tend not to put dish washers in rental apartments, those who rent install their own."* (Architect).

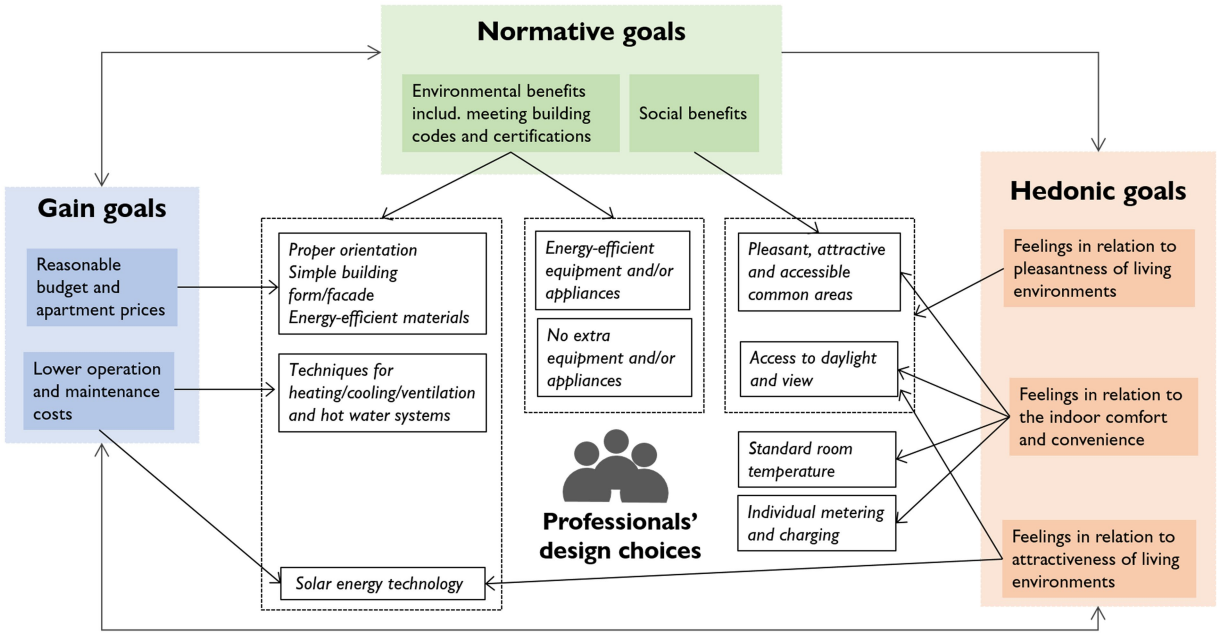

FIGURE 2
Relationships between the goals and their influence on design choices (indicated by the arrows between the boxes).

Participants weighted the normative goal relating to social benefits differently when making design choices relating to shared or common areas. Some of them felt that such areas could be highly prioritized because of the need to satisfy challenging energy requirements.

> *"The energy requirements are getting tougher, we really need to do a lot…. in one case we needed to reduce window areas by 25%, which was really hard because we wanted to have them (windows). We solved the problem by removing most of the windows from the staircase; those windows were large and looked nice, but we had to take most of them away."* (Engineer).

As demonstrated in this quote, the pleasantness of a common area (a staircase) resulting from large windows providing ample natural light and a pleasing view was reduced to satisfy stringent energy requirements. Another participant mentioned that it was common to reduce the space allocated to common areas in order to provide a better standard of living inside the apartments. In contrast, the normative goal relating to social benefits was prioritized in rental apartment buildings, where living space was reduced to provide larger common areas that were intended to promote social interaction between the building's end-users. Decisions about common areas were also sometimes guided by a gain goal frame.

> *"…We talk a lot about it (common areas) – it used to be mostly about common areas for gardening but now it's more about (the areas) where people can meet. /…./ We built the apartments in (neighborhood name). A three-room apartment is 59 m², which is rather small, and we see that people may dislike that, but on the other hand it makes them (the apartments) cheaper. I am not sure, it might also reduce their energy consumption."* (Housing company representative).

The normative goal relating to environmental benefits was also found to motivate design choices concerning common or shared areas that were intended to promote energy-saving or environmentally friendly behaviors through the perceived pleasantness, attractiveness, or accessibility of the areas.

> *"We have stairs of course and they have natural light and are the simplest way to go up and down …. There are elevators too, but they are dark and boring so you only use them when you have to. The stairs are also visible from the outside and they are turned towards entrance balcony."* (Architect).

This quote illustrates how the design choices chosen for common areas were expected to promote energy-saving behavior, i.e., using stairs instead of an elevator. Moreover, a design choice providing easy access to a bike room had been suggested as having a potential to facilitate biking, but had not been preferred considering gain goals.

> *"People should have a bike room at the entrance so that they do not have to go down to the basement to get their bikes; they should feel that they can just get on their bike and go. These 'soft' things, they have not started coming in/…./. Putting a bike room above ground takes away space that could be used for apartments, which means losing a lot of money."* (Architect).

In relation to a normative goal frame, participants also mentioned that there are attempts to reduce the environmental impact of buildings over their entire life-cycle, and that more holistic approaches to sustainable design and development of multifamily buildings are needed. Five participants (one architect, two engineers and two project developers or housing representatives) stressed that sustainable building materials and more efficient use of materials are becoming increasingly important issues when considering cost effectiveness together with energy efficiency and comfortable indoor environments during the buildings' use phase. It is also increasingly recognized that the pros and cons of technological solutions must be evaluated holistically, and that it will become necessary to strike an optimal balance between these different considerations, which can be related to the three goal frames, by compromising on certain design choices.

> *"I think these conflicts we have today may become more intense in future, so I think we will have to make compromises and say what is important here and why do we make certain choices, and if we have documented those discussion and compromises then we will be able to talk to the building regulators or city planning offices and say these are the problems, this is how we have solved them."* (Architect).

Goal frames guiding choices of dwelling

The importance of goal frames

Building end users assigned different importance scores to the six aspects of energy-efficient multifamily buildings that were described in the questionnaire (Table 1), and there were significant differences between the scores assigned to each item: $H(5, n = 364) = 36.96$, $p < 0.001$. The end-users assigned the highest importance score to the availability of apartment amenities (item 2), which is related to pleasantness, comfort, and convenience and is thus linked to the hedonic goal frame. The next most important aspects were easy and low-effort maintenance of the apartment (item 4) and the affordability of the apartment (item 3), both of which reflect gain goals. Less important issues were the availability of good common areas (item 6) and the green or environmental certifications of the building (item 5), which reflect normative goals. The least important aspect was the building having a unique style or character (item 1), which was associated with a hedonic goal, i.e., a feeling of interest or excitement.

The score for the hedonic goal of apartment amenities was significantly higher than that for the normative goals of good common areas: $U = 1323.50$, $z = -2.86$, $p < 0.005$, $r = 0.26$ and the building's environmental certification: $U = 1097.00$, $z = -4.13$, $p < 0.001$, $r = 0.38$, and the hedonic goal of the building's style and character: $U = 833.50$, $z = -5.28$, $p < 0.001$, $r = 0.48$. The score for the gain goal of easy and low-effort apartment maintenance was significantly higher than that for the normative goal of the building's environmental certification: $U = 1322.50$, $z = -2.97$, $p < 0.005$, $r = 0.27$, and for the hedonic goal of the building's style and character: $U = 1108.50$, $z = -4.13$, $p < 0.001$, $r = 0.37$. Moreover, the score for the gain goal of affordable apartment cost was significantly higher than that for the hedonic goal of the building's style and character: $U = 1249.50$, $z = -3.20$, $p < 0.005$, $r = 0.29$.

Relationships between the goal frames relating to dwelling choice

The relationships between the aspects corresponding to gain, hedonic and normative goal frames based on the six different items on the questionnaire are presented in Table 2. There were few relationships between different items and goal frames, i.e., a moderate correlation between the two items corresponding to gain goals: $r_s = 0.48$, $n = 60$, $p < 0.01$, and weak correlations between the normative goal of the building's environmental certification and the hedonic goal of the building's style and character: $r_s = 0.28$, $n = 61$, $p < 0.05$, and the gain goal of affordable apartment cost: $r_s = 0.35$, $n = 60$, $p < 0.01$.

Comparing goal frames expressed by professionals and building end-users

The analysis of the professionals' views revealed that the selection of design choices was driven primarily by a normative goal relating to environmental benefits, specifically, the need to comply with building energy codes or obtain environmental building certifications. Gain goals relating to controlling investment costs, minimizing operating and maintenance costs, and offering apartments at affordable prices were found to play significant ancillary roles in determining the energy efficiency of the designed building and the provision of good and attractive living environments insofar as possible. The professionals were aware that the choices they made to limit energy use could reduce the aesthetic quality, pleasantness, comfort, and convenience of the buildings' living environments. The normative goal relating to social benefits was found to be particularly important in guiding design choices relating to the buildings' common or shared areas, which were often made with the aim of promoting social interaction. The normative goal relating to environmental benefits also motivated design decisions to make common or shared areas accessible, pleasant, and attractive in order to facilitate energy-saving or environmentally friendly behaviors. The idea that buildings' common or shared environments can have environmental benefits is supported by an earlier study on household energy use (Gram-Hanssen, 2013), which suggested that energy efficiency increases when more people share a living space. However, the professionals weighted the importance of the buildings' common areas differently to the living environment inside the buildings' apartments.

Whereas the building's environmental certifications were the most important consideration for the professionals, they were among the least important factor governing the dwelling choices

TABLE 1 Mean and median importance scores, and mean rank, for the six items included in the questionnaire for building end-users.

Item	*n*	*M*	SD	Mdn	Mean rank
(2) The apartment has amenities that I appreciate (a hedonic goal)*	60	4.45	0.53	4.00	228.10
(4) Maintaining the apartment is easy and requires little effort on my part (a gain goal)*	61	4.26	0.75	4.00	207.52
(3) The apartment is affordable (a gain goal)*	60	4.15	0.80	4.00	193.33
(6) The building has good common areas such as a laundry room and a bicycle room that can be used by all residents (a normative goal)	61	4.02	0.85	4.00	176.80
(5) The building is certified as an environmental building or equivalent (a normative goal)	61	3.77	1.01	4.00	154.94
(1) The building has a distinct style and character (a hedonic goal)	61	3.67	0.83	4.00	135.23

*The score was significantly higher when compared to some of the other items.

TABLE 2 Relationships between the six building aspects and the three goal frames.

	Hedonic goal frames		Gain goal frames		Normative goal frames	
	(1) Building's style and character	(2) Apartment amenities	(3) Apartment cost	(4) Time and cost of maintenance	(5) Green/ environmental certification	(6) Common areas
(1)	1	0.25	−0.90	0.009	0.28*	0.13
		$n = 60$	$n = 60$	$n = 61$	$n = 61$	$n = 61$
(2)		1	0.009	0.34	0.21	−0.06
			$n = 59$	$n = 60$	$n = 60$	$n = 60$
(3)			1	0.48**	0.35**	0.45
				$n = 60$	$n = 60$	$n = 60$
(4)				1	0.11	−0.03
					$n = 61$	$n = 61$
(5)					1	0.16
						$n = 61$
(6)						1

*$p < 0.05$, and; **$p < 0.01$.

of the buildings' end-users, who instead prioritized amenities, easy maintenance, and affordability. The latter two aspects both relate to gain goals and were found to be associated with each other. Moreover, their importance in end-users' decision-making aligns well with the emphasis that professionals place on minimizing operating and maintenance costs and ensuring that apartments are affordable when making design choices that may affect monthly fees (for user who purchase apartments) or rents (for rental apartments). The buildings' common areas were substantially less important than the amenities within the apartments in the end-users' decision making. To some degree this finding is consistent with the professionals' view that common areas are of lower priority than apartments, although this view did not apply to rental apartments, where professionals preferred to reduce the size of apartments to increase the size of the common areas for enhancing social interaction. The least important aspect

according to the end-users was the building's distinct style and character; this aspect was assigned a significantly lower importance score than all other aspects except the environmental and social aspects (which both correspond to normative goals). This outcome is consistent with the professionals' belief that a building's appearance must sometimes be sacrificed in favor of more important design choices.

It is notable that end-users assigned very different importance scores to two aspects linked to hedonic goals, namely, (i) the provision of apartment amenities, and (ii) the style and character of the building; there was no relationship between the importance scores for these two aspects. Accordingly, the comfort and convenience of the living environments played a greater role in the professionals' design choices than the style and character of the building (it was not possible to evaluate the relationship between such aspects in the case of the professionals). However, professionals felt that one design choice—adding solar panels to a building—gave it a special character as well as the ability to generate its own energy, so this design choice was driven by a combination of normative, hedonic and gain goals. This design choice was seen as something with the potential to trigger interest or excitement among prospective apartment buyers or renters, and to communicate information about the building's energy consumption and environmental friendliness. This may partly reflect the end-users' perception that a building's environmental certification was related to its style and character as well as the cost of its apartments, although these associations were rather weak.

Taken together, the general findings indicate a consistency between the views of professionals and building-end users on a gain goal frame relating to costs for living in the apartments, and that their views on normative and hedonic goal frames were rather inconsistent. The findings from the interviews suggest that the professionals strived to find optimal balances between the related aspects of normative and hedonic goals when working with the design and development processes of the buildings and the selection of design choices. On the other hand, the findings of the building end-users' views suggest that the building end-users would pay more attention to apartment amenities which contribute to pleasantness, comfort and convenience of the living environments rather than common areas, environmental certifications and special appearance of the buildings when making dwelling choice. These findings suggest that new approaches to building design and development are needed to satisfy the needs and preferences of end-users while simultaneously encouraging them to adopt sustainable lifestyles.

General conclusion

The paper aimed to clarify which aspects of modern energy-efficient multifamily buildings are considered important by the professionals who design them and by the buildings' end-users who live in them. Using goal-framing theory (Lindenberg and Steg, 2007, 2013; Steg et al., 2014) as a framework, aspects that guide professionals' design choices and end-users' dwelling choices were identified and compared. The findings provide insights into the goals that govern how both groups of actors, who interact with the buildings at different stages of their life-cycles, evaluate different aspects of such buildings.

The interviews confirmed the roles of goal frames and revealed which aspects of energy-efficient multifamily buildings are of interest to professionals. These aspects were subsequently coded and linked to specific goal frames. The constructs of goal-framing theory were readily apparent within the participants' responses and made it possible to construct a rich description of the goals that drive the design decisions taken by members of this group, irrespective of their individual roles in the process of building design and development. While the dominating goal frame was a normative goal relating to energy codes and environmental building certifications, a range of other goals also influenced the professionals' design choices. In particular, the goal of maximizing environmental benefits was constrained by the gain goals of staying within a predefined budget and ensuring low operating and maintenance costs. The combination of these normative and gain goals limited the scope for satisfying hedonic goals relating to the quality of the living environment. These hedonic goals were related to building aspects such as aesthetics, pleasantness, attractiveness, comfort, and convenience. Another aspect subordinated to the dominant normative and gain goals was social interaction, which was related to a normative goal. A major challenge for the professionals was striking an optimal balance between reducing a building's energy use and providing pleasant, comfortable, and convenient living environments. The relative importance of different goal frames appeared to vary between areas of the building; in particular, normative goals relating to social benefits appeared to have a stronger influence on design choices concerning common or shared areas of buildings than on choices relating to other areas. Taken together, the findings suggest that the professionals' design choices were guided by multiple goal frames rather than just one. This outcome is consistent with the results of an earlier study that used goal framing theory to describe the goal frames that motivated the adoption/rejection of energy-efficient lighting (Johansson et al., 2015).

End-users living in energy-efficient multifamily buildings assigned different priorities to the different aspects of the buildings. The most important aspect driving the dwelling choices of the end-users was linked to a hedonic goal (i.e., seeking pleasantness, comfort, or convenience). However, the least important aspect for end users was also associated with a hedonic goal (seeking pleasure or interest from the building's appearance). End-users also assigned high importance to two aspects that corresponded to gain goals, namely easy and low-effort maintenance (which corresponds to the gain goal of saving time and money) and apartment affordability (which corresponds to the gain goal of preserving economic resources). End-users considered both of these aspects to be more important than social and environmental aspects corresponding to normative goals.

Some aspects might not easily be interpreted as a singular goal frame. As an example easy and low-effort apartment maintenance would save end-users' time and money, and was therefore considered to reflect a gain goal. However, it could also be interpreted as a reflection of a hedonic goal (avoiding having to invest substantial effort into maintenance). Similarly, the aspect of convenience could save end-users' time, so one could argue that it should be associated with a gain goal but in this work it was instead grouped with pleasantness and comfort and linked to a hedonic goal. Regarding the different interpretations, we have assigned these aspects to the likely focal goal frames according to the principle that the long term consequences would weight higher in the choice of an apartment. This was based on the housing functions such as status symbol, self-representation, security and privacy that affect the quality of life (Pagani and Binder, 2021). For example, ones may value convenience the dwelling offers as an attribute of comfortable, safe, pleasant or attractive living environments (hedonic goal) rather than saving a few minutes during the day (gain goal). However, this shows that individual building aspects can be linked to multiple overlapping goal frames. Interestingly, although a relationship between the two aspects corresponding to gain goals was found, there were no significant relationships between any of the aspects corresponding to hedonic or normative goals. This is somewhat consistent with the analysis of the professionals' views, which indicated that there was no clear connection between the pleasantness, comfort or convenience of the apartments and the appearance of the living environments. These results show that different aspects reflecting the same goal frame are not always related. On the other hand, it should be noted that the professionals did think about the relationship between environmental and social benefits when making design decisions; the design of common areas was mentioned as having the potential to influence both environmental and social benefits.

It is interesting to compare the view of professionals and building end-users on different aspects of energy-efficient multifamily buildings through different goal frames. Their views on the economic aspects reflecting gain goals were closely aligned, but the same was not true for aspects reflecting normative and hedonic goals. Our findings indicate that end-users generally consider pleasantness, comfort and convenience aspects (which reflect hedonic goals) to be more important than aspects reflecting normative goals. This is important when considering the question of whether buildings with good energy performance can be considered sustainable if they are disliked by their users (Hay et al., 2018). The professionals highlighted the challenge of striking an optimal balance between different buildings aspects, which is exemplified by their struggles to simultaneously increase energy efficiency and the quality of the living environment. This can be understood in terms of the relationship between the different goal frames and their effects on design choices. Professionals believed that some design choices could convey information to end-users about energy and encourage the adoption of energy-saving or environmentally friendly behaviors. However, the potential of design choices to trigger undesired rebound effects must also be accounted for.

A few remarks on the methods should be made. First, the view of building end-users on different aspects of dwelling choices was captured only by few items as part of the POE. In further studies, it would be desirable to develop the POE instrument to include more items to cover other aspects of the goal frames as well as to systematically investigate relationships among these items (e.g., by means of a factor analysis). Second, the survey was used to collect data from the users. Though the view of the users could not be directly compared to that of the professionals, interviews with building end-users would be desirable to obtain a more nuanced understanding and to obtain a basis for further item development. In line with Zou et al. (2018), conducting qualitative study would improve understanding of the quantitative results. Patterns among the goals identified from interviews would also improve the comparison of goal frames between the groups of different actors.

Moreover, sustainable choices could be influenced by other drivers such as habits, attitudes, personal norms, knowledge together with the physical and social contexts (e.g., Klöckner and Blöbaum, 2010; van den Broek and Walker, 2019). To identify individual and contextual factors that play crucial roles in fostering or hindering personal choices, such drivers and their relationships with the goals frames should further be examined. The role of social contexts of different building phases should also be taken into consideration. In line with Johansson et al. (2021), this would provide an opportunity of holistic evaluation capturing the effects of social processes on the individual actors and the goal frames guiding their choices. There are different forms of social processes that could influence how the individual actors look at situations and evaluate goals (Gifford and Nilsson, 2014; Yang et al., 2021). In further research, it would be beneficial to integrate other psychological factors and possible drivers of sustainable choices to the goal-framing theory. It would also be desirable to examine the relations between social processes and the goal frames, and attempt to systematically identify both physical and social characteristics of living environments that contribute to sustainable values of buildings and promote sustainable lifestyles through a holistic approach.

The present work clarifies the relationships between different goals and the challenge of striking an optimal balance between them when making design choices, especially in cases where multiple goals create contradictory requirements. Methods for overcoming such challenges may be relevant in efforts to meet more general goals outside the context of building design such as the UN's sustainable development goals. As such, they could play important roles in motivating decision making. Overall, this work shows that goal framing theory is a powerful framework for understanding and integrating the perspectives of different actors who interact with buildings in different phases of their life cycles. In this way, it provides a basis for constructive discussion about the design and development of energy-efficient multifamily buildings that motivate their residents to adopt or maintain sustainable lifestyles and at the same time promoting healthy living environments.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: Ethical guidelines, i.e., the participants were informed that the data will be collected and used for the specific research project and the results will be published. The informed consent did not include data sharing issues. Requests to access these datasets should be directed to pimkamol.mattsson@abm.lth.se.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

PM and MJ contributed to conception and design of the study, and conducted data coding. PM collected and initially analyzed the data, and wrote the first draft of the manuscript. MJ contributed to revision. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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What does the public think about microplastics? Insights from an empirical analysis of mental models elicited through free associations

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Microplastics are an issue of rising concern, in terms of their possible implications for both the environment and human health. A survey was distributed among a representative sample of the adult Norwegian population (N = 2720) to explore the public understanding of microplastics. Respondents were asked to report the first thing that came to mind when they read or heard the word "microplastics," based on which a coding scheme was developed that served to categorize the obtained answers into thematic clusters. Results indicate that the public seem to think of microplastics as something bad that might pollute the ocean and harm animal species. Awareness of the sources of microplastics appeared to be rather low, and few respondents mentioned potential ways to solve the problem. Responses differed across certain socio-demographic characteristics; for example, female and younger respondents were more likely to think about the spread and causes/sources of microplastics, whereas a higher educational level was associated positively with thinking of ways to solve the problem. Additional analyses indicated relationships between personal values and the identified thematic clusters; for example, endorsing self-transcendence and openness-to-change values was associated with thinking of ways to solve and of consequences of microplastics. These findings are informative to those wanting to design tailored communications and interventions aimed at reducing plastic pollution and plastic waste.

KEYWORDS

microplastics, free associations, mental models, personal values, plastic pollution

Introduction

Public concern about the consequences of microplastics has been growing in recent years, including concern about possible effects on the environment and on human health (European Commission, 2019; SAPEA, 2019). The existing literature suggests that attitudes and knowledge about microplastics can predict various behaviors

contributing to the mitigation of related emissions (Deng et al., 2020), and that exploring public opinion and knowledge about plastic litter is pivotal for the successful implementation of policies targeting plastic pollution (Forleo and Romagnoli, 2021). This has led scholars to point out the need to develop insights into public understanding of microplastics in order to develop effective solutions to this evolving global challenge (Heidbreder et al., 2019; Henderson and Green, 2020). The present study takes a mental models approach in order to identify factors that may determine public support for (or opposition to) behaviors and policies addressing microplastics.

Mental models[1] are mental representations of an event or situation constructed from available information, such as their respective causes and consequences (Bostrom, 2017). There is a growing literature suggesting that mental models can guide policy support and individual behavior in response to environmental challenges. For example, flawed mental models of climate change may be important in explaining support for "wait and see policies" (Sterman and Sweeney, 2007, p. 1). Other studies have employed mental models to reveal subjective beliefs that influence support for when, why, and how species and ecosystems should be conserved (Moon et al., 2019), or to identify factors associated with behaviors among local people from a coastal community that contributes to extensive plastic leakage into the ocean (Phelan et al., 2020). It is commonly assumed that the insights gained from exploring laypeople's mental models about environmental issues can be used to inform the design of tailored risk communication strategies (Bruine de Bruin and Bostrom, 2013; see also Morgan et al., 2002).

One way of tapping into people's mental models are free associations, which can be elicited from responses to open-ended questions. This method has been employed to study people's associations with bioplastics (Dilkes-Hoffman et al., 2019a) but also with plastic more generally (Dilkes-Hoffman et al., 2019b). Few studies have investigated the public understanding of microplastics specifically, and therefore, knowledge about mental models regarding this issue is still scarce. Perhaps the public is not aware of the connections between their personal use of products containing microplastics and environmental pollution, which is important for the consideration of mental models, given the relevance of causes and consequences as their components. An exploration of free associations with microplastics can thus provide novel insights into how laypeople think about the issue, which in turn may predict behaviors and policy endorsements. Associations reflecting causes and consequences might be particularly relevant, since they have been argued to make up the most important components of mental models (Bostrom, 2017).

A lack of public awareness of the issue is illustrated by two empirical studies that conducted focus groups in the United Kingdom. One study investigated perceptions of microplastics in personal care products, concluding that the public might not be aware that consumer goods such as personal care products are sources of microplastics (Anderson et al., 2016). Another study reported that the public, despite frequently associating microplastics with impacts on the ocean, may not understand the process of how microplastics reach marine environments (Henderson and Green, 2020). The picture that emerges from these two studies is that rather than focusing on its origin, associations with microplastics mainly relate to their environmental impacts. It has been argued that these perceptions could be shaped by media narratives that tend to focus on the ubiquity of microplastics and its potential impacts on animal species (Deng et al., 2020; Völker et al., 2020). Media narratives also often highlight the end stages of plastic's lifecycle (e.g., when plastic can be reused or recycled) instead of focusing on earlier stages (e.g., when plastic gets produced; Dilkes-Hoffman et al., 2019a).

It is well recognized that a person's value orientation can shape the perceived importance and perceived consequences of environmental issues (Steg et al., 2014). Schwartz (1992, 1994) value theory postulates ten different clusters of basic human values[2] along two axes; one axis ranging from conservation (security, tradition, and conformity) to openness-to-change (hedonism, self-direction, and stimulation) and the other from self-transcendence (universalism and benevolence) to self-enhancement (hedonism, achievement, and power). Since microplastics can have implications that go beyond concerns for one's personal interests such as individual health, self-transcendence values might be particularly relevant to understanding people's associations with microplastics[3]. Other research has demonstrated that a greater emphasis on self-transcendence values is linked to pro-environmental behavior (Liobikienë and Juknys, 2016) and higher concern about plastic litter (Hartley et al., 2018). Thus, those with strong self-transcendence values might be more concerned about potential threats, and more likely to mention consequences, when they think about microplastics. Those who emphasize self-enhancement values might on the other hand be less inclined to consider possible impacts in relation to microplastics,

1 This conceptualization of mental models shares conceptual similarities with social representations, which have been defined as "organized sets of opinions, knowledge, attitudes, and beliefs about a social object … co-constructed and shared by a social group" (Fasanelli et al., 2020, p. 1).

2 These are "desirable trans-situational goals, varying in importance, that serve as guiding principles in the life of a person or other social entity" (Schwartz, 1994, p. 21).

3 Self-transcendence values are those which go beyond a focus on the self and prioritize the welfare of other people, the community, or the environment (Cheung et al., 2014). In contrast, self-enhancement values give little consideration to others in personal decision-making and lead to attitudes and behaviors focused on the self (Urien and Kilbourne, 2011).

given that self-enhancement values are typically negatively linked with environmental concern (Steg and De Groot, 2012).

Research aim

This study takes an exploratory approach to provide a better understanding of how the public thinks about microplastics, based on an analysis of responses to an open-ended question. Microplastics are often seen as an issue of public concern due to their potentially harmful consequences for the environment (European Commission, 2019; Deng et al., 2020), and impacts on the environment and the ocean appear to be common associations when people are asked to elaborate on their views on plastic and microplastics (Dilkes-Hoffman et al., 2019b; Henderson and Green, 2020). We therefore expected that consequences, particularly those pertaining to environmental impacts, will be the most prevalent associations in a representative sample of the adult Norwegian population. Additional analyses explored whether individual differences can be predicted by value endorsements, in response to scholars calling for more research on how values may shape public perceptions of microplastics (Pahl and Wyles, 2017; Rist et al., 2018; Kramm et al., 2022).

Methods

Sample

We analyzed data that were obtained through the Norwegian Citizen Panel (NCP). The NCP is a research-purpose internet panel based on a probability sample of the general Norwegian population above the age of 18 drawn from the Norwegian National Registry. The NCP runs two to three waves of data collection each year and recruitment is conducted by postal invitation. Participants receive no payment for participating, but in each wave, there is a lottery, where three people win a travel gift card, each valued 8000 NOK. A total of N = 2720 respondents were included in the present analysis, which combined data from Wave 11 (2018), Wave 17 (2020), and Wave 18 (2020). Sampling weights for gender, age, education, and geography were applied to compensate for possible sampling bias. The distribution of these four socio-demographic variables in the sample can thus be assumed to reflect that in the general Norwegian population[4].

4 For details, including recruitment and sampling procedures for each panel wave, see https://nsd.no/nsddata/serier/norsk_medborgerpanel.html.

Materials

Free associations

Participants responded to the following open-ended question: "What do you think of when you hear or read the word 'microplastics'?" They received the following instructions: "Please write down the first thing that comes to your mind. We appreciate all kinds of answers, preferably a few sentences, or just a few words if this suits you better." Similar question wording was employed in previous studies that explored perceptions of plastic-related issues (Dilkes-Hoffman et al., 2019a,b).

A coding system was developed after an initial screening of the responses, alongside consultation of prior research addressing microplastics (e.g., Boucher and Friot, 2017). The resulting coding scheme consists of six superordinate categories, each divided into one or more second- and third-level categories (see **Table 1**). The complete coding scheme including coding instructions, definitions, and example responses for each category is provided in the **Supplementary Material**. The six superordinate categories are: (i) ways to solve (i.e., the response indicates that something needs to be done in order for the problem of microplastics to be solved or reduced, or references some type of action to address or tackle microplastics, such as international cooperation or regulations, e.g., "the government needs to penalize plastic usage"), (ii) consequences (i.e., the response refers to potential impacts of microplastics, such as environmental pollution or effects on the economy, e.g., "harming animals"), (iii) evaluations (i.e., the response expresses some type of evaluation of microplastics, such as the importance of the issue or the feasibility or difficulty of tackling the problem, e.g., "they are a very complicated problem to address"), (iv) spread (i.e., the response refers to where microplastics can be found, such as in the ocean, soil or food, e.g., "they are in the air"), (v) sources/causes (i.e., the response refers to where microplastics might originate or come from, or what provokes the release or production of microplastics, such as the plastics industry or washing fleeces, e.g., "car tires"), and (vi) remnant category (i.e., mere descriptions or responses that did not fit with any category).

The responses could be coded at three different levels of specificity. For example, the "consequences" category has three second-level categories (personal, societal, and environmental consequences), which in turn encompass further third-level categories. A response such as "microplastics cause pollution in the environment" would be coded as follows: consequences / environmental consequence / environmental pollution (cf. **Table 1**). Two university students (native Norwegian speakers) coded the responses after having been trained in using the coding system. First, the two coders coded the responses independently. They agreed on 98.2% of all codes. Then,

they were asked to go through the responses they had coded differently and to resolve their disagreements to the extent possible.

Personal values

Personal values were measured *via* the Ten-item Value Inventory (TIVI; Sandy et al., 2017), an ultra-brief version of the Portrait Values Questionnaire (PVQ; Schwartz, 2003). The 10 values assessed by the TIVI are as follows: conformity, tradition, benevolence, universalism, self-direction, stimulation, hedonism, achievement, power, and security. The order of the items was randomized per respondent. Universalism, benevolence, achievement (reversed) and power (reversed) values were combined into the self-transcendence versus self-enhancement dimension. Conformity, security, stimulation (reversed), self-direction (reversed) and hedonism (reversed) values were combined into the conservation versus openness-to-change dimension. Higher positive values represent more self-transcendence and more conservation values, relative to self-enhancement and openness-to-change, respectively; for a similar approach studying the relative importance of personal values for explaining public perceptions of environmental issues, see Poortinga et al. (2019). We treated each individual's mean response to all items as a covariate to partial out the effect of individual differences in mean response level, while leaving the distribution of responses within individuals unchanged (Schwartz, 1992).

Socio-demographics

In addition to gender (1 = male, 2 = female) and age (1 = born 1959 or earlier, 2 = born 1960-1989, 3 = born 1990 or later), the analyses incorporated a categorical measure on education (1 = completed primary school or below, 2 = completed secondary school, 3 = college or university degree). These socio-demographics were included as covariates based on previous studies addressing public perceptions of plastic-related issues; for example, women tend to report greater concern about plastic pollution (Dilkes-Hoffman et al., 2019b; Forleo and Romagnoli, 2021) and stronger behavioral intentions to engage in mitigation actions (Hartley et al., 2018; Deng et al., 2020).

Analyses

First, we inspected the frequencies of the categories in the coding scheme, excluding the remnant category. To assess if the obtained responses reflect different degrees of richness, we calculated the average word count for each response. An individual respondent's word count was considered as a dimension of richness (cf. Andrews and Lamb, 2017). To explore

TABLE 1 Frequencies of free associations with microplastics across each of the identified categories.

Codes			Category	Percentage		
Level 1	Level 2	Level 3		Level 1	Level 2	Level 3
1			**Ways to solve**	**10.5**		
	1.1		International level		1.1	
	1.2		National policy level		4.0	
		1.2.1	Regulation *via* incentives			0.6
		1.2.2	Regulation *via* penalties			1.2
		1.2.3	Need for facilitation			1.0
		1.2.4	Increase knowledge			0.6
	1.3		Level of citizens within society		3.0	
		1.3.1	Change behavioral lifestyle			2.0
		1.3.2	Change attitudes and values			0.1
		1.3.3	Collective action			0.3
		1.3.4	Increase awareness			0.8
	1.4		Business and industry		0.5	
	1.5		Respondent engagement		0.8	
		1.5.1	Already taking action			0.4
			Does not want to take action			0.1
2			**Consequences**	**51.9**		
	2.1		Personal consequences		5.7	
		2.1.1	Financial resources			0.0
		2.1.2	Personal comfort			0.0
		2.1.3	Personal health			2.4
	2.2		Societal consequences		0.4	
		2.2.1	Societal risks			0.2
		2.2.2	Social justice / equity			0.0
		2.2.3	Economy			0.0
	2.3		Environmental consequences		47.9	
		2.3.1	Environmental pollution			21.5
		2.3.2	Environmental preservation			0.0
		2.3.3	Environmental aesthetics			0.0
		2.3.4	Consequences for animals			10.6
		2.3.5	Consequences for plants			0.5
		2.3.6	Consequences for the food chain			3.8
3			**Evaluations**	**36.5**		
	3.1		Concerning feasibility to tackle		10.7	
		3.1.1	Easy to tackle			0.1
		3.1.2	Difficult to tackle			10.6
	3.2		Concerning effectiveness of potential measures		0.8	
	3.3		Concerning importance		2.5	
		3.3.1	Important for the present			0.4
		3.3.2	Important for the future			0.9
	3.4		Expressions of skepticism		1.1	
		3.4.1	Skepticism toward underlying intentions of stakeholders			0.4

(Continued)

TABLE 1 (Continued)

Codes			Category	Percentage		
Level 1	Level 2	Level 3		Level 1	Level 2	Level 3
		3.4.2	Skepticism toward scientific understanding			0.1
	3.5		Expressions of affective valence		27.6	
		3.5.1	Positive valence			0.7
		3.5.2	Negative valence			26.5
	3.6		Expressions of conflict-laden aspects		2.0	
		3.6.1	Conflict between different impacts			1.1
		3.6.2	Conflict between different generations			0.5
4			**Spread**	**48.7**		
	4.1		Aquatic environments		34.1	
		4.1.1	Saltwater			31.6
		4.1.2	Rivers			0.8
		4.1.3	Lakes			0.3
	4.2		Land / soil		2.1	
	4.3		Air		0.3	
	4.4		Animals		8.9	
		4.4.1	Fish			5.7
		4.4.2	Whales			1.4
	4.5		Plants/flora		0.3	
	4.6		Drinking water		1.3	
	4.7		Food		4.5	
	4.8		Humans		5.2	
5			**Causes/sources**	**24.1**		
	5.1		Fleece, clothing		9.4	
	5.2		Sewage treatment		0.2	
	5.3		Car tires		0.7	
	5.4		Artificial grass turf		3.3	
	5.5		Litter		7.4	
	5.6		Personal care products		3.2	
	5.7		Agriculture		0.1	
	5.8		Paint		0.1	
	5.9		Industry		2.3	
		5.9.1	Fishing			0.4
		5.9.2	Aquaculture			0.1
6			**Remnant**	**12.3**		
	6.1		Mere descriptions		6.8	
	6.2		Non-codable responses		4.1	
	6.3		Does not know		1.4	

Percentages are based on n = 2527 (adjusted for weights). First-level categories are displayed in bold. Sampling weights for gender, age, education, and geography were applied in the analyses.

whether thinking about some topics co-occurs with thinking about other topics, we calculated correlations among the main categories. Second, we conducted multiple logistic regression analyses to assess how well socio-demographics and personal values predict free associations with microplastics, with the main categories as the criterion. All analyses were carried out with IBM SPSS Statistics for Windows, Version 27.

Results

Free associations

Figure 1 shows that consequences of microplastics (51.9%) were the most frequent main category, dominated by references to environmental impacts (cf. Table 1). Only a few responses referenced personal consequences, and almost no references to societal consequences were made. Some of the mentioned environmental consequences could further be specified into environmental pollution, followed by impacts on animals and consequences for the food chain.

The second most frequent category was spread (48.7%), which indicates where respondents believe that microplastics can be found. Within this category, references to aquatic environments dominated the responses, comprising saltwater, rivers and lakes. The next most frequent second-level category is spread of microplastics to animals, among which most respondents mentioned fish and only a few mentioned whales. Second-level categories within spread, that were comparable in terms of frequency, included humans, food, and soil. The least frequent second-level categories regarding where microplastics can be found were drinking water, plants and the air.

The third most frequent main category by a notable margin was evaluations (36.5%). The most prevalent type of evaluation regarding microplastics were expressions of affective valence, which could be positive or (predominantly) negative. The second most frequent type of evaluation was evaluations concerning the feasibility of addressing microplastics, which were dominated by views that microplastics are a difficult problem to tackle. Few responses reflected evaluations concerning the importance of microplastics, conflict-laden aspects of microplastics, skepticism, or statements regarding the effectiveness of potential solutions.

Sources/causes of microplastics, that is, references to where microplastics are believed to come from or be produced, were mentioned in approximately a quarter of the total responses (24.1%). The most frequent second-level categories among potential sources of microplastics were fleece and clothing and litter. A few responses mentioned artificial grass turf, personal care products, and industry, while a very small number mentioned car tires, sewage treatment, agriculture and paint.

The least frequent of the main categories was ways to solve the problem (10.5%). References to actions that might or should contribute to solving or mitigating the problem were dominated by responses referring to national policies, among which penalties were the most frequent third-level category. Slightly fewer responses mentioned demands of citizens within society, and even fewer referred to the international level.

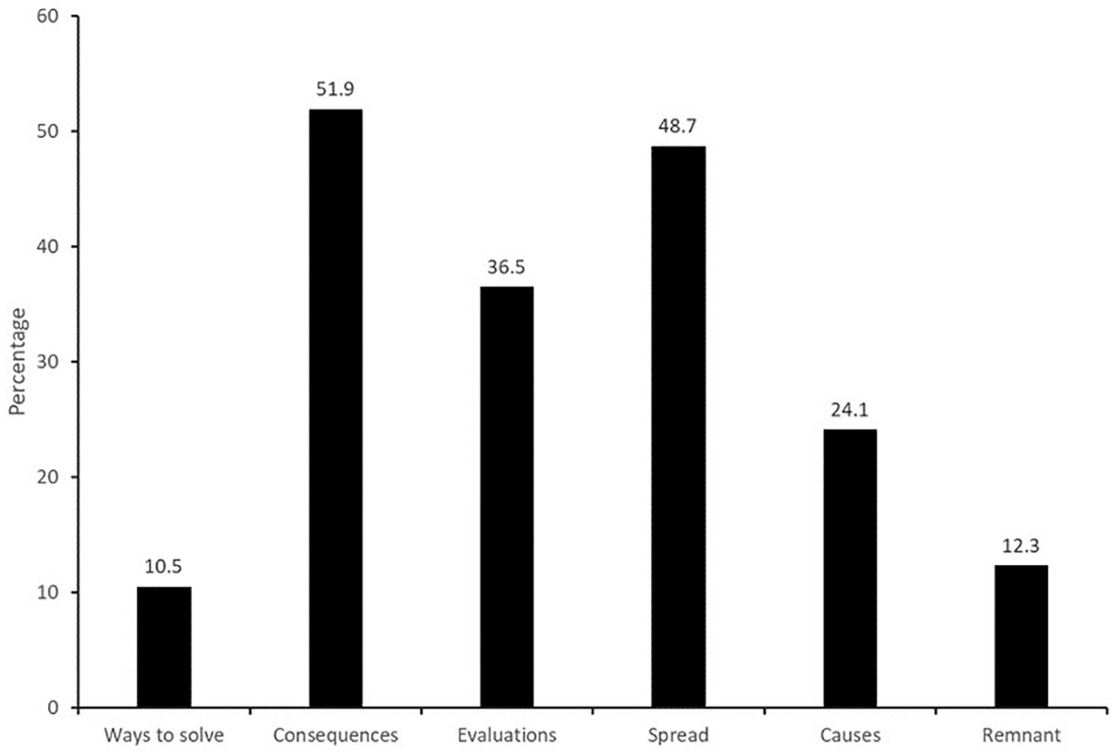

FIGURE 1
Frequencies of first-level categories (percentages).

Figure 2 shows that average word count per response was 11.8. The category with the highest average word count by far is ways to solve the problem of microplastics (26.6), followed by causes/sources (18.6), evaluations (17.4), spread (where microplastics can be found; 16.2) and consequences (13.4). The remnant category has by far the lowest average length (4.6).

The category showing the highest correlations with other categories was evaluations. Table 2 shows that expressing an evaluation correlated positively with ways to solve and with consequences, but negatively, and less strongly, with sources/causes and with spread. Moreover, a small negative correlation was found between consequences and causes/sources, whereas a small positive correlation was observed between spread and causes/sources. Lastly, ways to solve showed small positive correlations with causes/sources and with consequences, and a small negative correlation with spread.

Predicting free associations from socio-demographics and personal values

We conducted a series of multiple logistic regression analyses, each considering one of the main categories of free associations with microplastics as the dependent variable and socio-demographics and personal value orientations as predictors (see Table 3). While an odds ratio greater than 1 indicates a positive association (e.g., with endorsing self-transcendence values), an odds ratio lower than 1 indicates a negative association (e.g., with endorsing conservation values). Gender was entered as a dichotomous predictor, with male respondents as the reference category; the corresponding odds ratio represents the likelihood for females to mention a main category compared to the likelihood for males. Age was entered as a continuous predictor, with three groups ordered from youngest to oldest; the odds ratios represent the likelihood that someone older thinks of ways to solve microplastics, for example, compared to the likelihood for younger respondents. Education level was treated as a continuous predictor, ranging from the lowest to highest level of education; odds ratios higher than 1 indicate that a higher educational level increases the odds of the corresponding outcome.

Males are more likely than females to think about ways to solve the problem of microplastics. A higher level of education increases the odds of mentioning ways to solve microplastics. Furthermore, both value dimensions are significantly related to thinking about ways to solve the problem. Those who prioritize self-transcendence over self-enhancement have higher odds of mentioning ways to solve microplastics, whereas those who

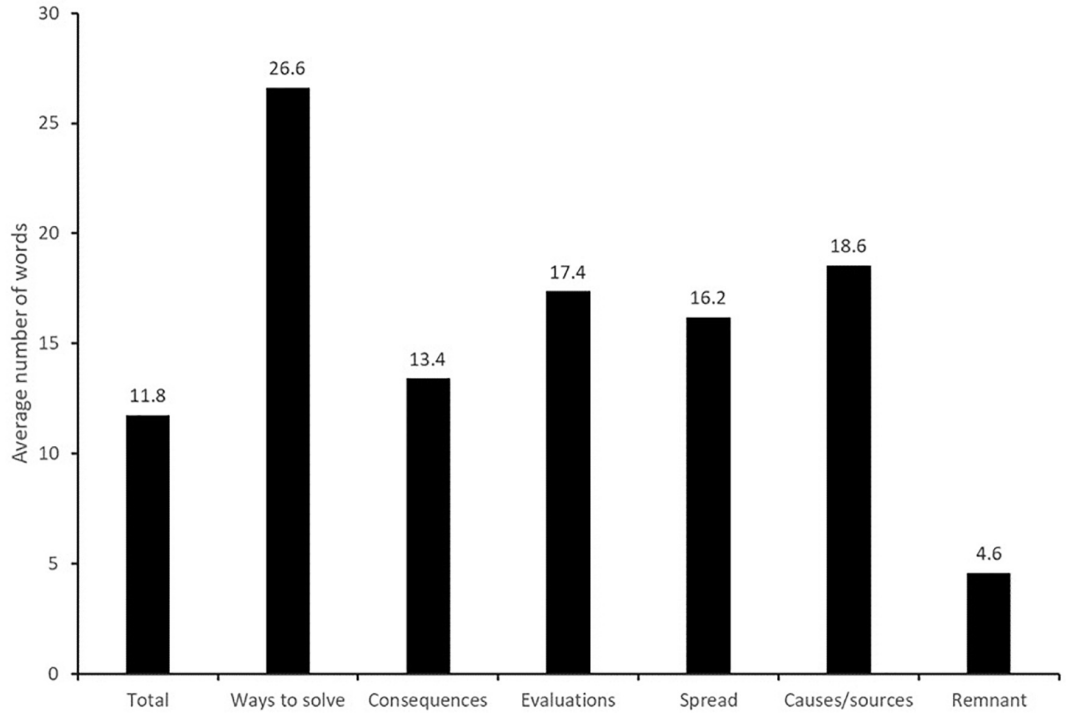

FIGURE 2
Average number of words of responses for each first-level category.

TABLE 2 Intercorrelations among free associations with microplastics.

Variables	1	2	3	4	5
1. Ways to solve	-				
2. Consequences	0.044**	-			
3. Evaluations	0.240***	0.319***	-		
4. Spread	−0.060**	0.007	−0.105***	-	
5. Causes/sources	0.057**	−0.099**	−0.081***	0.117***	-

Pearson correlations (two-tailed). **$p < 0.01$ and ***$p < 0.001$.

prioritize conservation over openness-to-change have lower odds of thinking of potential ways to solve the problem of microplastics.

Moreover, both value dimensions were significantly related to referencing consequences of microplastics. While those prioritizing self-transcendence values over self-enhancing values have higher odds of thinking about consequences, those prioritizing conservation values over openness-to-change values have lower odds of referencing consequences when thinking about microplastics.

Concerning evaluations of microplastics, females are more likely to give evaluations than males. Females also have higher odds than males of mentioning the spread of microplastics (i.e., where microplastics can be found). People higher in age have lower odds of referencing the spread as well as the causes/sources of microplastics.

Lastly, females have higher odds than males of thinking about where microplastics come from or are produced. When it comes to personal values, those who endorse conservation values have lower odds of thinking about sources of microplastics. Predictors not mentioned in the preceding paragraphs did not exhibit a significant association with the corresponding outcome category.

Discussion

Respondents mainly associated microplastics with possible consequences, often in connection with environmental consequences, and less often in relation to personal impacts. While it was also mentioned where microplastics can be found, such as in aquatic environments and the ocean, expressed views on possible causes/sources appeared to be somewhat vague. This is in line with studies suggesting that the general public might not be very aware of the sources of microplastics (Anderson et al., 2016; Deng et al., 2020; Henderson and Green, 2020). Clothing and litter were the most common sources people thought of, and there were only very rare references to other relevant sources of microplastics such as car tires or industry. One interpretation is that people do not seem to

TABLE 3 Logistic regressions predicting free associations with microplastics.

	Ways to solve		Consequences		Evaluations		Spread		Causes/sources	
Variables	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Socio-demographics										
Gender (Female)	0.674	[0.510, 0.890]	1.115	[0.941, 1.322]	1.212	[1.016, 1.446]	1.239	[1.044, 1.470]	1.664	[1.361, 2.034]
Age group	1.140	[0.930, 1.397]	0.909	[0.802, 1.030]	1.095	[0.962, 1.247]	0.782	[0.690, 0.887]	0.794	[0.690, 0.959]
Education	1.010	[1.002, 1.018]	0.994	[0.987, 1.000]	1.006	[1.000, 1.013]	1.005	[0.999, 1.012]	1.005	[0.998, 1.012]
Personal values										
Self-transcendence vs. self-enhancement	1.250	[1.004, 1.557]	1.191	[1.041, 1.364]	1.026	[0.982, 1.181]	0.938	[0.820, 1.074]	1.145	[0.977, 1.342]
Conservation vs. openness-to-change	0.723	[0.575, 0.908]	0.831	[0.722, 0.957]	0.950	[0.821, 1.100]	0.987	[0.779, 1.033]	0.81	[0.689, 0.959]
Constant	0.082**		0.628		0.203**		1.629		0.588	
Model χ^2	25.391***		25.986***		17.526**		39.500***		49.153***	
Nagelkerte (pseudo R^2)	0.023		0.015		0.011		0.023		0.032	

CI, confidence interval for odds ratio (OR).
Sampling weights for gender, age, education, and geography were applied in the analyses. $^{**}p < 0.01$ and $^{***}p < 0.001$.

fully understand the processes by which microplastics end up in the ocean, as already noted in the existing literature (Henderson and Green, 2020).

Ways to solve the problem of microplastics made up the least frequent association, and if this category was mentioned at all, the obtained answers were very unspecific. Similar findings have been reported in other studies (e.g., Anderson et al., 2016; Henderson and Green, 2020). Although evaluations were a frequent association people made in our study, the types of evaluations people made mostly concerned ascribing a negative affective valence to microplastics, and, to a lesser extent, reflecting on the feasibility of tackling the problem. The finding that most respondents did not mention and may not be aware of potential ways to solve the problem might contribute to the lack of more varied types of evaluations. It is possible that if participants were more aware of possible ways to reduce microplastics pollution, they would make more varied evaluations concerning different aspects of microplastics, such as the importance of the issue or the effectiveness of these potential solutions. This complements existing literature calling for greater communication efforts in order to focus on solutions as well as threats concerning microplastics (Veiga et al., 2016).

A large proportion of our respondents associated microplastics with something bad, which might reflect patterns in how the media report on the topic. Völker et al. (2020) conducted an empirical analysis of media framings and argue that media reports use three main narratives: (i) that microplastics are present in the environment in large numbers, (ii) that microplastics are present in food and beverages, and (iii) that microplastics contain toxic chemicals which might be ingested by animals. Our results showed that many respondents indeed associated microplastics with their presence in the environment, mostly marine environments, but also perceived a connection with environmental pollution and harming animals. The narrative of finding microplastics in food and beverages did not resonate within the surveyed population, with only a few respondents making these associations (for similar findings, see Henderson and Green, 2020).

One aspect contributing to the observed pattern of associations might be the tendency to relate plastic to stages at the end of its lifecycle, such as the moment of purchase or the moment of release into the natural environment, rather than to its production and other characteristics. This tendency could be due to the end-of-life being the stage at which consumers interact with plastic packaging, making them feel responsible for decisions regarding its disposal (Herbes et al., 2018), or that end-of-life impacts are easier to understand and communicate, meaning that this stage is most often discussed in the media (Dilkes-Hoffman et al., 2019a). Our analyses regarding the richness of responses seems to support this interpretation: references about ways to solve the problem were on average the longest, whereas references to consequences were the shortest. It has been argued that message length is an indicator for deliberation in online communications (Liu and Zhang, 2020). Therefore, the differences in richness between consequences and the other categories, together with the fact that references to consequences were generally most prevalent, could mean that laypeople associate microplastics with their consequences more intuitively than with possible sources or with ways to solve the problem.

Female respondents were more likely to think of where microplastics are found as well as of their sources/causes. Nonetheless, they were less likely to think of ways to solve the problem. Younger respondents thought more frequently of the spread and sources of microplastics. This is in line with findings that age can predict attitudes and intentions in related domains, such as marine threats (Lotze et al., 2018), beach

litter (Rayon-Viña et al., 2018), and concern over the health of marine environments (Potts et al., 2016). People with higher education levels were more likely to think of ways to solve the problem of microplastics, aligning with studies investigating individual differences in perceptions of plastic pollution more broadly (Hartley et al., 2018; Deng et al., 2020; but see Dilkes-Hoffman et al., 2019b). Education has been argued to play a key role in increasing awareness and changing behaviors and attitudes to preserve environmental resources (Forleo et al., 2019) and education campaigns are considered necessary for the implementation of successful policies to mitigate plastic marine pollution (Clayton et al., 2021).

Aside from demonstrating associations with socio-demographics, the analyses suggest that perceptions about microplastics can (to some extent) be predicted from a person's value orientation. This was indicated by the finding that endorsing self-transcendence (rather than self-enhancement) values was associated with considering potential consequences of microplastics, and with a greater likelihood to think of potential ways to solve the problem. Individual endorsements of conservation (rather than openness-to-change) values was negatively related to associating microplastics with ways to solve, consequences, and causes/sources. These findings corroborate studies that have linked self-transcendence values with concern about potential threats posed by plastic litter in the more general sense (Hartley et al., 2018), and expand upon literature that has reported mixed findings regarding the influence of conservation and openness-to-change values on environmental perceptions (e.g., Schultz and Zelezny, 1999; Milfont et al., 2015; Poortinga et al., 2019).

Limitations

Free associations are a non-directive method of eliciting spontaneous connections that people make when they are asked to think about a word or expression (Dany et al., 2015). While this method can be useful in particular when there is not much knowledge about a given topic, its application in research addressing the public understanding of microplastics remains not without certain challenges. One such challenge concerns the notion that categorizing content into thematic groupings (or clusters) may not be independent from the meaning that the investigating researchers ascribe to the obtained responses (Lo Monaco et al., 2017). We aimed to account for this by employing two independent coders so that interpretations would not be made by a single person, and by developing a multilevel coding scheme so that each answer could be categorized at different levels of specificity. An alternative way to improving reliability of thematic groupings might have been to ask respondents to express the meaning that they would like to give to their association (e.g., Piermattéo et al., 2014), and/or to ask them for a justification for all associated terms (e.g., Galli and Fasanelli, 2020).

Conclusion

The present study provides incremental evidence about what members of the public associate with microplastics, with references to consequences and the spread of microplastics making up the most common themes among the surveyed population. A substantial share believed that microplastics can accumulate in marine environments, produce environmental pollution, have negative impacts on animal species, and on a more general note, they perceived microplastics as something bad and harmful. Rather than focusing predominantly on potential harmful impacts, information campaigns may benefit from combining facts about specific sources of microplastics with practical guidance on how individual actions in everyday life might contribute to mitigating the problem. This follows the notion that knowledge of behavioral options and potential action strategies are among the most important types of knowledge associated with pro-environmental behavior (e.g., Kollmuss and Agyeman, 2002). Future research could aid the development of such campaigns by focusing on more concrete aspects related to microplastics, and by considering further personal and structural factors that may shape how members of the public perceive the risks and benefits of microplastics.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics Statement

Ethical review and approval was not required for this study in accordance with the local legislation and institutional requirements. The Norwegian Citizen Panel dataset, on which this study is based, deals with human subjects and follows the EU General Data Protection Regulation (GDPR). According to this, a Data Protection Impact Assessment (DPIA) was conducted and approved by the University of Bergen. The DPIA was conducted in cooperation with the Norwegian Agency for Shared Services in Education and Research (Sikt). The DPIA number is 118868. In addition, the Scientific Committee of the Norwegian Citizen Panel reviews all questions that are to be fielded in each panel wave. Participation in the panel is by written informed consent, and data are always treated confidentially.

Author contributions

MFR, GB, and RD contributed to the conception and design of the study. MFR performed the statistical analyses and wrote the first draft of the manuscript. All authors contributed to manuscript revision, and read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.920454/full#supplementary-material

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Give Up Flights? Psychological Predictors of Intentions and Policy Support to Reduce Air Travel

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Concerted, timely action for mitigating climate change is of uttermost importance to keep global warming as close to 1.5°C as possible. Air traffic already plays a strong role in driving climate change and is projected to grow—with only limited technical potential for decarbonizing this means of transport. Therefore, it is desirable to minimize the expansion of air traffic or even facilitate a reduction in affluent countries. Effective policies and behavioral change, especially among frequent flyers, can help to lower greenhouse gas emissions. For both, a positive evaluation and public support is indispensable. This study contributes to understanding air travel behavior and the perception of regulative policies. We examined the role of attitudes, perceived behavioral control, efficacy, global identity, and justice concerns for intentions to avoid flights and aviation-related environmental policy support. We conducted an online survey study with a quota sample of N = 2,530 participants in Germany. The strongest positive predictors of intentions to refrain from flying and policy support were perceived behavioral control to travel without flying, efficacy beliefs that avoiding air travel contributes to climate change mitigation, and intergenerational justice concerns; pro-travel attitude was a negative predictor. Moreover, we tested whether the provision of additional information on climate impact, global and intranational inequalities as well as subsidies (implying intranational inequality) affected the intention to avoid air travel and policy support. We found no effects of the different types of information. Nor did we find an interaction between the type of information provided and global or national identity. Our results highlight the need for a shift within the mobility sector that facilitates attractive and accessible transport alternatives in order to strengthen people's behavioral control to choose other means than planes and their efficacy perceptions. Moreover, raising awareness of the impacts of climate change on future generations and developing strategies to promote people's concern for intergenerational justice might motivate people to reduce air travel and thereby contribute to a livable future for new generations.

Keywords: pro-environmental behavior, policy support, sustainable mobility, intergenerational justice, efficacy beliefs, perceived behavioral control

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INTRODUCTION

The latest IPCC report states that human-induced climate change is progressing fast and with drastic, irreversible consequences that are already observable and measurable (IPCC, 2022a). Greenhouse gas savings need to be promoted in all sectors to achieve the Paris climate protection targets (UNFCCC, 2015; IPCC, 2018). Aviation is responsible for approximately 2–3% of annual global CO_2 emissions with the non-CO_2 emissions not yet accounted for (Klöwer et al., 2021; EASA, 2022). Lee et al. (2021) estimated that CO_2-warming-equivalent emissions stemming from aviation are three times higher than merely considering CO_2 emissions. Prognoses state that aviation emissions could account for 25% of the global carbon budget by 2050 (Graver et al., 2019).

Decarbonizing aviation is technically challenging and requires significant investments (Chiaramonti, 2019). Therefore, alongside the need to address these technical challenges, a change in mobility behavior to cut fuel demand is of particular importance (Davison et al., 2014; Transport and Environment, 2018). This is especially the case, since reductions in CO_2 emissions through efficiency and fuel switch are predicted to be negated by growing demand (Kahn Ribeiro et al., 2007). According to Gössling and Humpe (2020), existing policy plans and mitigation targets (e.g., under the Kyoto Protocol and Paris Agreement) ignore a large part of emissions. In the realm of passenger flights, efforts are deployed to make tourism more sustainable and reduce greenhouse gas emissions from travel (Gössling, 2009). Aviation accounts for a majority of the tourism sector's CO_2 emissions (Gössling, 2009). Expanding environmentally friendly mobility alternatives (e.g., trains) and promoting sustainable travel choices can thus aid in curbing emissions and decarbonizing the transport sector.

Hence, changes on different levels are needed: on the technological, political but also individual level (Transport and Environment, 2018, 2021). The latter two are especially relevant from an individual and societal perspective. First, public support is advantageous for the implementation of effective policy measures to reduce air traffic. Examining factors that increase and maintain policy support will allow recommendations on how to promote a climate-friendly mobility infrastructure and its usage.

Second, planes are taken by people—the aggregate individual mobility decisions represent the demand for air transportation. The advent of the Fridays for Future movement sparked debate about the environmental impact of air travel. It culminated in media reports discussing the need for and prevalence of "flight shame" (Gössling et al., 2020). Understanding the determinants of people's intentions to refrain from flying could contribute to lowering carbon emissions through encouraging behavioral change accordingly.

Third, accessible sustainable alternatives to air travel are needed. For example, switching to (night) trains instead of planes constitutes a relevant option for reducing emissions (European Environment Agency, 2020). Research on travel mode choices found that people, for example, consider travel time and costs (Román et al., 2007) and familiarity (Dällenbach, 2020). A recent study showed that the perceived behavioral control over choices between modes of transport was associated with reduced airplane usage (Dütschke et al., 2022).

Our study contributes to understanding people's intentions and policy support to reduce flying by examining further potentially relevant psychological factors next to perceived behavioral control over travel options: people's travel and environmentally careless holiday attitudes, their efficacy beliefs in positive outcomes of flight avoidance, concerns for intergenerational justice as well as their global identification.

From a societal point of view, air travel is related to various inequalities. First, air travel is linked to intragenerational inequalities in two regards. On a global level, more people take planes in the Global North vs. the Global South [e.g., Latin America and the Caribbean accounted for 5.1% of passenger kilometers in 2019, Africa for 2.1%, and Europe for 26.8%; ICAO (2019)]. At the same time, many countries of the Global South are disproportionately affected by climate change (IPCC, 2022a). On a national level, air travel is highly subsidized but only a small amount of people tends to fly on a regular basis and thus profits from these subsidies—usually with high socioeconomic status (Gössling and Humpe, 2020). Second, the consequences of climate change will be experienced mostly by younger and future generations implying intergenerational inequalities (Page, 1999; Fleurbaey et al., 2014). These inequalities, and whether people perceive them as injustices, have received little attention in previous research explaining individual behavior and policy support. Thus, we examined whether the salience of different forms of air travel-related inequalities influences people's intentions to avoid flights and support for aviation-related policy measures. Our study was conducted in Germany, a high-income country with comparatively good infrastructure for air, rail, and car travel.

THEORETICAL BACKGROUND

Air Travel as Environmentally Relevant Behavior

Within the last years, flying has received more attention as an impactful environmentally relevant behavior due to its relevance for climate change mitigation (Gössling and Humpe, 2020). Reflections about the freedom of choice and the necessity of traveling by plane will not be targeted in this paper [see Gössling et al. (2019), for a respective discussion]. Rather, we aim to understand people's motivation to reduce air travel. According to Stern (2000), environmentally relevant behaviors can be differentiated in high vs. low impact behaviors and private vs. public sphere behaviors. With regard to the high impact behavior of air traveling, people can decide to privately reduce their behavior in the mobility system and to support certain public policies and regulatory frameworks that shape or change this mobility system (Steg and Vlek, 2009; Dekoninck and Schmuck, 2022).

In this study, we investigate determinants of both individual intentions to refrain from air travel as well as support for policies that encourage the reduction of air travel. Previous studies have identified various factors that influence individual

mobility choices and support for environmental policies [for overviews, see Drews and van den Bergh (2016) and Lanzini and Khan (2017)]. In the following section, we derive the specific contribution of our study to this research field.

Socio-Economic Correlates of Air Travel Behavior

High income (Böhler et al., 2006; Büchs and Schnepf, 2013) as well as higher levels of education (Böhler et al., 2006) are generally correlated with individual greenhouse gas emissions. Moreover, socio-economic characteristics are relevant for explaining mobility patterns in general, and air travel in specific. For example, both income and level of education predicted the frequency and distance of long-distance trips (Holz-Rau et al., 2014; Reichert and Holz-Rau, 2015). Dütschke et al. (2022) found that income and education predicted past flying behavior, with education being the stronger predictor. Only education predicted behavioral intentions to reduce long-distance travel. Regarding policy support, socio-economic (and further demographic) factors appear to have only a minor explanatory value (Ejelöv and Nilsson, 2020). Kallbekken and Sælen (2021) infer from the limited evidence that findings are inconsistent but policy support seems to be typically stronger among people with higher income. In the present study, we therefore also examine the role of income and education.

Psychological Determinants of Air Travel Behavior

An abundance of research has identified psychological predictors of environmentally relevant behaviors in general [for an overview, see e.g., Bamberg and Möser (2007), Klöckner (2013), and Gifford and Nilsson (2014)] and mobility behaviors in particular (Lanzini and Khan, 2017). According to the widely applied Theory of Planned Behavior (TPB, Ajzen, 1991), attitude, subjective norms, and perceived behavioral control toward a specific behavior are important determinants of many (pro-environmental) behavioral intentions and behaviors [for a review and guidance on the application of the TPB to pro-environmental behavior, see Yuriev et al. (2020)].

Past research on air travel found that particularly differences in attitudes and perceived behavioral control explained differences in behavior. While a pro-travel attitude (i.e., valuing freedom of travel choices and opportunities to travel frequently) was positively related to air travel choices, pro-environmental holiday attitude was negatively related (i.e., caring about the environment when planning vacation, see Barr and Prillwitz, 2012). In a recent study, Dütschke et al. (2022) found that people who perceived a higher behavioral control to travel without flying were less likely to have used a plane in the past and reported higher intentions to use more sustainable travel modes than air travel in the future. Next to behavioral control, the extent to which people believe that their behavior effectively leads to desirable outcomes is considered to impact sustainable behavioral choices (Hanss and Böhm, 2010). Accordingly, Doran et al. (2015) found that efficacy beliefs about one's own contribution to environmental protection predicted the willingness to accept economic sacrifices when choosing traveling options. This is relevant to refraining from air travel as flying is often cheaper than alternative transport modes (Carrington, 2021). In accordance with the TPB, Davison et al. (2014) found that subjective social norms, but also personal norms [see e.g., Norm Activation Model, Schwartz (1977) and Schwartz and Howard (1981)], predicted the selection of alternatives to air travel and flight frequency. Contrarily, Dütschke et al. (2022) found no association between social and personal norms with intentions to refrain from flying. In our study, we focus on pro-travel attitude, environmentally careless holiday attitude (i.e., not caring about the environment when planning vacation), perceived behavioral control, and efficacy beliefs that reducing aviation contributes to climate change mitigation.

Individual behavior change can only make a difference on a large scale if many people (especially from affluent countries) alter consumer choices. Therefore, the collective dimension of environmentally relevant behavior has received greater attention in recent years. Particularly, it has been argued that people's identification with relevant social groups might drive pro-environmental behavior [see e.g., Ferguson et al. (2016) and Fritsche et al. (2018)]. Social Identity Theory and Self-Categorization Theory state that people do not only define themselves as individuals via different aspects of their personal identity but also as members belonging to different social groups (Tajfel and Turner, 1986; Turner et al., 1987). Moreover, people can also identify on a global level with all humanity. Some authors have thus examined the relevance of a global identity (i.e., perceiving a group membership with all humanity, McFarland et al., 2012, 2019), for counteracting environmental crises (e.g., Running, 2013; Der-Karabetian et al., 2014; Barth et al., 2015; Joanes, 2019; Loy and Reese, 2019; Loy and Spence, 2020; Loy et al., 2022a). Loy et al. (2022b), for example, argued that global identity could serve as driver to act in collective instead of self-interests when it comes to climate change mitigation. They found that identification with people all over the world predicted self-reported climate-protective behavior and behavioral intentions. Römpke et al. (2019) argued that intergroup contact could promote collective action to solve global crises *via* strengthening global identity. The authors found that international contact increased global identity and also diverse pro-environmental and social behaviors.

Global identity might be particularly relevant when it comes to air travel. On the one hand, global identity might drive people's interest in long-distance journeys and thereby foster air traveling. On the other hand, it might prevent people from this highly CO_2-intensive behavior threatening their global ingroup [see (Loy et al., 2021)]. Previous research revealed mixed evidence so far. Römpke et al. (2019) found no relation between global identity and the intention to avoid air travel. Loy et al. (2021) found a positive relation between global identity and self-reported previous refrain from air travel as well as policy support to decarbonize the mobility system. Global identity was not associated with how frequently people had stayed abroad and negatively with CO_2 emissions calculated from self-reported previous flights. However, global identity was positively related to the quantity and quality of contact with locals during traveling and situationally increased when participants were asked to think of past international travel experiences. Therefore, Loy et al. (2021) concluded that global identity seems to be no

hindrance for decarbonizing mobility, including the willingness to fly less, even though in-depth international contact seems to be advantageous. In our study, we thus included global identity as further possible predictor of people's intention to refrain from flying.

Psychological Determinants of Policy Support

In addition to personal mobility behaviors, approval for policies that regulate air traffic is also important for decarbonizing transport. Past literature identified several factors that influence approval of environmental policies, such as the perceived fairness and effectiveness of policies, risk perception, concern and knowledge about environmental problems, trust, values, political orientation, or social norms (Kallbekken and Sælen, 2011; Drews and van den Bergh, 2016; Fairbrother et al., 2019; Bergquist et al., 2022). However, most of the conducted studies dealing with policy support in the transport sector focus on everyday behavior (i.e., reduction of car usage, diffusion of electric vehicles or modal shift; Schade and Schlag, 2003; Pridmore and Miola, 2011; Schuitema et al., 2011; Schmitz et al., 2019). Only few studies have specifically focused on support for environmental policies regarding long-distance travel, and in particular, aviation [see e.g., Kallbekken and Sælen (2021)]. Kallbekken and Sælen (2011) found that next to many of the above-named variables, perceived effectiveness, perceived threat and imminence of problems, knowledge, trust, and expected negative effects of policy measures on the self and the poor explained policy support.

As argued for intentions to reduce air travel, also respective policies might be favored by globally identified people. Accordingly, Loy and Reese (2019) found that the stronger people's global identity, the stronger they supported climate policies [see also Loy et al. (2022a)]. More specifically, Loy et al. (2021) found a positive correlation between global identity and support of policies to decarbonize the mobility system. In our study, we thus included global identity as further possible predictor of people's policy support.

Moreover, the perceived fairness of policies is a particularly strong correlate of policy acceptance (Bergquist et al., 2022). Fairness perception might depend on individual justice concerns as well as the salience of inequalities. Therefore, in the following, we discuss the relation between air travel and different inequalities and related justice concerns, and how these concepts were integrated into our study.

Air Travel and Its Relation to Different Inequalities

Even though the terms inequality and injustice are related to each other and both used in this article, they are not equivalent (Hegtvedt and Isom, 2014). Inequality refers to a rather objective circumstance that can be determined by judging parameters (e.g., income). Injustice, in turn, implies a subjective assessment of these circumstances. What is perceived as just and unjust differs between individuals (Hegtvedt and Isom, 2014), for example, depending on how justified they consider inequalities between people (Reese et al., 2014). The perception of (in)justice and moral reasoning are relevant aspects of psychological functioning and explain how people behave (Killen and Dahl, 2021). People may (re-)act differently to perceived moral norm violations and injustice according to their individual definition of (in)justice and a general sensitivity for (in)justice (Dar and Resh, 2001). In order to understand people's behavior, it is therefore crucial to identify people's moral and justice ideals and concerns (Rothmund et al., 2016).

A growing body of research has linked people's justice perceptions to environmental issues (Clayton et al., 2016; Jenkins et al., 2016; van der Horst et al., 2021; Zabern and Tulloch, 2021). In debates on energy transition, several inequality issues have been pointed out [see e.g., Jenkins et al. (2016)]. The distribution of resources and costs (Meyer, 2019) but also energy consumption and resulting emissions (Pellegrini-Masini et al., 2020) entail relevant (distributional) inequalities. For example, Oswald et al. (2020) report that among 86 countries, the top 5% consume more than 20% of the final energy use. This inequality in energy consumption, however, does not translate into a corresponding burden sharing of the (negative) impacts. Even though climate change threats are expected to affect all people, vulnerable groups, particularly in the Global South, are most strongly endangered (Parks and Roberts, 2006).

When the perception of injustice leads to feelings of anger, it is considered to initiate action against this injustice, including collective action (Landmann and Rohmann, 2020). In our research, we are interested in distributional justice regarding the accessibility and (negative) impact of air travel. In the following, we outline how air travel is related to different distributional inequalities and how perceiving them as injustices might be related to people's intentions to refrain from flying and support policies to reduce air travel.

Global Inequality

Global inequality is often associated with inequalities between people all over the world regarding economic parameters such as income and purchasing power (Milanovic, 2011) or poverty (Pieterse, 2002). Global inequality in terms of climate change refers to the unequal distribution of climate change effects (i.e., effects are stronger in the Global South compared to the Global North) as well as to the proportionate contribution causing the climate crisis [i.e., contribution is smaller in the Global South than in the Global North; IPCC (2022b)]. Climate change effects, in turn, will intensify economic inequalities (IPCC, 2022a). Several global injustice issues are debated regarding the aviation sector. For example, only a small part of the world population flies on a regular basis. Gössling and Humpe (2020) found that 1% of the world population is responsible for 50% of the CO_2 emissions resulting from commercial aviation.

Reese et al. (2014) showed that people who perceived global inequalities as injustice were more likely to intend actions in favor of global equality. Environmentally concerned and knowing people are generally aware of global injustices related to climate change (Waldron et al., 2019). At the same time, environmental concern (alone) is not necessarily associated with abstaining from air travel (Alcock et al., 2017). Still, people who considered global justice of resource use important reported stronger intentions to act pro-environmentally (Reese and Jacob, 2015). Reese et al. (2014) argued that globally identified people should particularly

perceive global inequalities as unjust. Accordingly, they found that the stronger people's global identity, the stronger their perception of global injustice, which in turn predicted their intentions to act in favor of global equality. Based on these results, Reese (2016) further argued that global identity might strengthen perceptions of global inequalities with regard to climate change effects and thereby motivate transnational efforts to mitigate climate change.

Inferred from this reasoning, we examined whether making global inequalities related to air travel salient influences people's intentions and policy support to reduce air travel and whether this depends on people's global identity.

Intranational Inequality

Inequality occurs not only at the global level but also at the intranational level. Many researchers examined economic and educational inequalities between citizens of a nation (Hoover, 1989; Odoardi et al., 2020). Moreover, an increasing number of studies outlined unequal climate change causation and distribution of climate change impacts at the national level (Rao, 2014; Oswald et al., 2020). Both considerations can also be applied to the context of air travel behavior. The aviation sector is a highly subsidized sector with several levels of government providing financial assistance to support airports, aircraft, and airlines. The cheap tickets made possible by this do not reflect the true costs of air travel (even without accounting for environmental externalities; Transport and Environment, 2019). Among various subsidies at regional, national, and EU levels, tax exemptions on fuel and tickets are often considered the largest subsidy (Transport and Environment, 2019; Gössling and Humpe, 2020). In addition, due to the COVID-19 pandemic and the subsequent decline in passenger travel, many countries have granted airlines great amounts of subsidies (e.g., loans, credit guarantees, and state aid) with mostly no climate or dividend conditions (Transport and Environment, 2021).

From an intranational equality perspective, the question arises what share of the population benefits from these subsidies that are enabled by all taxpayers (and accordingly emits greenhouse gas emissions). On a national level, the amount of people who don't fly (on an annual basis) outnumber those who do. Surveys indicate that the most frequent flyers (between 3.7 and 12% of the flying population depending on country and statistic) accounted for 28.8–68% of all flights [for more details, see Gössling and Humpe (2020)]. In addition, these frequent flyers who benefit the most from subsidized air travel tend to belong to the wealthy part of the population. From a distributional justice perspective, subsidies for air traffic thus raise allocational questions (Gössling and Humpe, 2020).

Similar to the motivating potential of global identity to reduce global injustice, Reese (2016) argued that a regional identity (e.g., national identity) might strengthen perceptions of regional injustices with regard to climate change effects and thereby motivate regional efforts to mitigate climate change.

Making the intranational inequalities (i.e., the subsidies) of air travel salient could thus encourage intentions to avoid flights and lead to higher support for policies that regulate air travel. These effects might depend on people's national identity.

Intergenerational Inequality

The duty of current generations to preserve the livelihood of future generations has been discussed from the perspective of various disciplines, especially philosophy and economics (Rawls, 1971; Tobin, 1974; Ball, 2001; McCormick, 2009; Hay, 2015). The imbalance of causing and carrying environmental problems between generations (Zabern and Tulloch, 2021) is referred to as intergenerational inequality, as the costs on ecosystems and humans will to a large extent be carried by younger and future generations (Hansen et al., 2013). In political debates, the necessity of viewing the impacts of certain policies from an intergenerational perspective is considered to be crucial in order to provide a sustainable societal and ecological system for the future (Buchanan, 2020). How this discrepancy is perceived and appraised will in the following be referred to as concern for intergenerational justice.

In the case of the climate crisis, the link between intergenerational injustice and climate change has already been made decades ago (Page, 1999). The notion of intergenerational injustice addresses questions regarding the distribution of social, economic, and cultural resources amongst present and future generations as climate change will impact the life of future generations adversely (Page, 1999; Skillington, 2019; IPCC, 2022a). Increasing air traffic and its impact on the climate contribute to the (possible) inability to keep the global temperature increase below 1.5°C compared to pre-industrial levels (Scott et al., 2015). With the rise of youth activists like Greta Thunberg and the Fridays for Future movement (Leung, 2020), the concept of intergenerational justice has gained increasing attention. Climate action was framed as an issue of intergenerational justice effort, aiming to preserve ecosystems for future generations (Zabern and Tulloch, 2021).

Gössling et al. (2020) provided examples of headlines from newspaper articles. They revealed that the relation of air travel with intergenerational injustice is perceived and communicated as moral concern. Reese and Jacob (2015) found that the more people valued intergenerational justice of resource use, the stronger their intentions to act pro-environmentally. This relation was mediated by feelings of moral anger and responsibility. Similarly, Syme et al. (2000) found that perceived intergenerational injustice motivates people to engage in pro-environmental behavior and support policy measures for protecting the environment.

Building on these findings, we examined whether intergenerational justice concerns are positively related to the intention to avoid air travel and the support for regulative policies to reduce air travel.

Aim and Hypotheses of the Study

The present study seeks to identify psychological factors that are associated with the intention to avoid flights and policy support to reduce air travel. The focus of this study is air travel behavior within Europe which is more or less easily replaceable by other transport means. We hypothesized that pro-travel and environmentally careless holiday attitudes are negatively related to intentions to refrain from air travel, while perceived behavioral

control to travel without flying, efficacy beliefs, global identity, and concern for intergenerational justice are positively related to intentions to refrain from air travel. With regard to policy support to reduce air travel, we assumed that global identity and concern for intergenerational justice are positively associated. Since intentions to avoid flights and policy support to reduce aviation are both expressions of pro-environmentalism [the former in the private sphere, the latter in the public sphere, see Stern (2000)], we also examined the variables that were not explicitly hypothesized as predictors of both.

In addition, we hypothesized that information on air travel-related global and intranational inequalities will encourage the intention to avoid flights and policy support to reduce air travel—depending on people's identity. Specifically, we expected that globally identified people might respond more strongly to information regarding the global injustice of air travel, while nationally identified people might respond more strongly to information regarding intranational inequalities induced by subsidies. To control for differences in knowledge, we included subjective knowledge regarding air travel's impact on climate change as control variable in the analyses. Moreover, we examined the role of income and education as well as further demographic characteristics (age, gender).

MATERIALS AND METHODS

The study was conducted in October 2019 as part of a bigger research project ("Sozio-E2S") assessing mobility and investment behavior for energy system modeling.

Study Design

In order to examine the relationships between the hypothesized psychological predictors and the two outcome variables (intentions and policy support to reduce air travel), we employed a questionnaire comprising all relevant variables and conducted regression analyses. We included a between-subjects experimental factor to analyze the effect of informing respondents about different inequalities related to air travel on intentions and policy support to reduce air travel. Participants were randomly assigned to one of four groups (three experimental conditions and one control condition). All groups received the same introductory information about the growth of air traffic. In addition, Experimental Group 1 received information about the environmental/climate effects of aviation. This group was added in order to compare inequality information to factual information on climate impact. Experimental Group 2 received information about aspects of global and intranational inequality of aviation, Experimental Group 3 about German subsidies for the aviation sector implying intranational inequality. The text information can be found in **Table 1**. The summary of the survey flow is depicted in **Figure 1**.

To check whether information was read and understood, we included manipulation checks after the information was provided (1. "Aviation accounts for a large share of the total climate impact of German greenhouse gas emissions", 2. "Emissions from aviation are (globally) unfairly distributed", 3. "(German) air traffic is heavily subsidized" answered on a 5-point Likert Scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Manipulation checks were successful except for the climate impact of aviation. No differences were found between the groups for this item. We assume that either the information text was not distinct enough in stressing the climate impact in contrast to the other groups, that participants were already similarly aware about the climate impact, or that the manipulation check was too vaguely formulated.

The survey was conducted online. Programming and data collection was done by the market research institute Aproxima GmbH. The questionnaire was sent to a quota sample of 2,800 citizens mirroring the population in relevant sociodemographic characteristics. An evaluation of the market research institute showed that the majority of respondents were very or rather satisfied with the questionnaire, which suggests a positive effect on response quality.

Sample

Sampling Procedure and Socio-Demographic Characteristics

Participants were recruited with quotas on age, gender, education, income, city size, and geographical region to ensure a distribution mirroring the German population (above the age of 16) in these characteristics (see **Table 2**). In total, 2,530 respondents completed the survey, from which 20 were omitted due to repetitive answer patterns. Respondents received incentives to participate from the provider of the online access panel. Data control for anomalies was carried out by the market research agency after the first 50 cases as well as in the evaluation phase.

Due to the quota system, the unweighted sample was close to the population in almost all parameters. Subsequent weighting was carried out primarily for the school-leaving qualifications "without a school-leaving qualification" and "university entrance qualification" and for the location size categories "under 5,000 inhabitants" and "5,000 to under 20,000 inhabitants." In the weighted sample, all parameters considered were less than 1% point different from the population. For conducting regression analyses we dummy-coded levels of formal education and gender. Higher education was coded as 1 (*university entrance certificate including "Fachhochschulreife" to university degree*) and 0 [*lower education*, see also Dütschke et al. (2022)]. In our sample 32.8% of the respondents held a higher education, thus mirroring the German population closely (32.4%). Gender was coded as 1 (*female, divers*) and 0 (*male*).

Air Travel Behavior and Modes of Transport

Of all participants, 84.7% indicated to have taken a plane before, 15% had never taken one, and 0.2% did not specify. Most participants had not taken a plane within the past 12 months at all within Europe. In the case of travel due to leisure/vacation reasons within Europe, two thirds of the respondents had not taken a plane at all (66.32%) and less than 10% had taken more than one return flight (1 single flight = 7.93%, 2 single flights = 17.58%, 3 single flights = 0.89%, 4 or more single

TABLE 1 | Information provided in the three experimental conditions and the control condition.

General information on passenger aviation (introduction for all conditions)
Air traffic is growing rapidly both globally and at European and national level. Since 1990, the annual number of passengers has increased by 100% globally—in Germany by as much as 243%. Within the next two decades, the International Air Transport Association expects a further doubling of air transport.
1. Experimental condition 1: Environmental effects
This makes aviation the industry with the fastest growing emissions. In addition to CO_2, other substances are released during a flight, which have varying degrees of warming or cooling effects. In total, however, they increase the climate impact of flying. Depending on the source, it ranges between a factor of 2 and a factor of 4 of the direct CO_2 equivalents ("Radiative Forcing Index RFI"). In 2017, air traffic in and from Germany generated about 31 million tons of CO_2 equivalents. If the non-CO_2 effects are included in the estimate (factor 3, see RFI), the climate impact of German air traffic would correspond to emissions of approximately 94 million tons of CO_2 equivalents. This means that the percentage of German aviation in the overall climate impact is around 9.7%.
2. Experimental condition 2: Aviation and justice
Emissions from air transport are unfairly distributed both globally and within Germany: it is estimated that less than 5% of the world's population has ever been on an airplane. Latin America and Africa account for only 11% of air traffic, while North America and Europe, with lower total populations, account for more than half. Overall, only a minority of Germans fly regularly. A recent survey by Infratest Dimap found that six out of ten people in Germany rarely or never fly at all. People in the highest income group in Germany fly an average of 6.6 times per year, while those in the lowest income group fly 0.6 times per year.
3. Experimental condition 3: Aviation and subsidies
The aviation sector in Germany is massively subsidized by the general public. Both indirect and direct subsidies are listed below: 1) Tax on kerosene By exempting kerosene from energy tax, the state waived the industry around seven billion euros in tax revenues every year. 2) Value-added tax/sales tax There is no VAT on international airline tickets, which means that the state loses around five billion euros in tax revenue. 3) Subsidies for airports in Germany 10 of the 16 international airports in Germany are in the red and permanently dependent on public subsidies. Of the 19 regional airports, not a single one is self-sustaining. As a rule, the annual loss is over 100 million euros. In addition, domestic air traffic alone caused external environmental costs (i.e., the health, environmental and climate damage to be borne by the general public) of 1.3 billion euros in 2017.
4. No additional information

flights = 7.28%; the maximum number of single flights in this group was 30, followed by 18 and 16 single flights). Younger and highly educated respondents in our sample tended to fly more than older and less educated respondents as illustrated in **Table 3**.

When asked about their preferred mode of transport for distances between 500 and 1,000 km, 50.5% of the participants reported to choose a private car, 27.6% a train, 13.2% a plane, 4.7% a public bus. Car sharing, car rental, and company cars were each preferred by less than 1% of the respondents.

We also asked participants to rank criteria that influence which mode of transport they choose for leisure activities. The criteria which were most important to our sample are travel time and price. Environmental friendliness was assigned a rather low importance by the respondents, with 41.6% naming it to be the least important criterion. To 6.4% of the respondents, it was the most important one. **Table 4** provides details about the importance of the criteria for means of transport.

Since night trains are a possible alternative option especially for trips to other European countries, we additionally assessed past use and attractiveness of night trains. For the majority of respondents, night trains were attractive both within Germany and within Europe (M_{Europe} = 3.63, SD = 1.24; $M_{Germany}$ = 3.5, SD = 1.3; scale ranging from 1 = *not attractive at all* to 5 = *very attractive*). However, 65% of respondents had never traveled on a night train. For 28%, it had "been a while" and only 7% had traveled by night train in the past two years. Several issues discourage our sample from using night trains more often. They named a lack of information (76%), that trains travel too infrequently (80%), are too expensive (27%), that no suitable connections are available for relevant destinations (22%), that night trains are not needed (26%), that they had not yet considered to travel by night trains (35%), that travel times of night trains are too long (13%), night trains are uncomfortable (13%), or other reasons (8.4%). Furthermore, 62% of the respondents rather or fully agreed that more night trains should be used within Europe, 10% rather or fully disagreed (M = 3.8, SD = 1.09; scale ranging from 1 = *don't agree at all* to 5 = *fully agree*).

Measures

Participants answered all items on 5-point Likert scales ranging from 1 (*don't agree at all*) to 5 (*fully agree*). A comprehensive item list with descriptions can be found in **Supplementary Table 1**.

Outcome Variables

Intention to avoid flights was measured with one item ("In the future, I will try to avoid flights in general"), following the concept of behavioral intention from the TPB (Ajzen, 1991).

Policy support was measured with eight items (e.g. "Overall, I am in favor of policies being put in place to reduce air traffic as a whole.", α = 0.91) following media discourses (e.g., Stay Grounded, 2022) and previous studies examining multiple policies in the transport sector (Schade and Schlag, 2003; Eriksson et al., 2008).

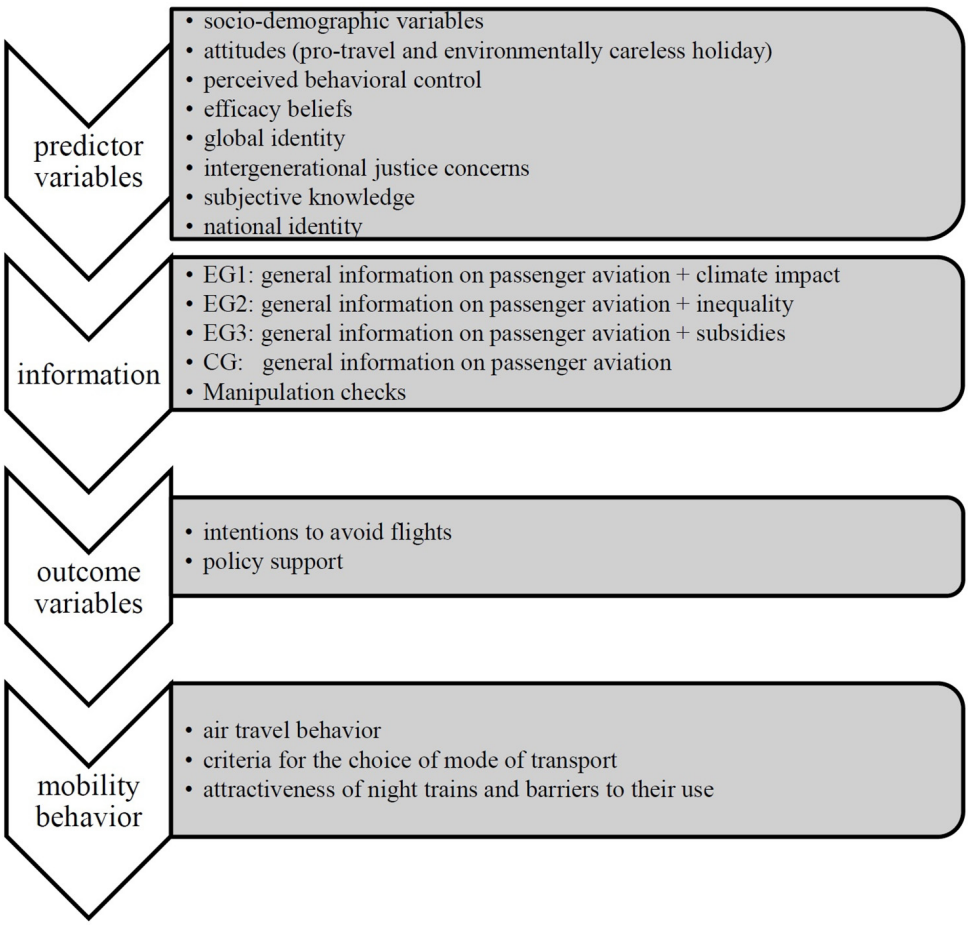

FIGURE 1 | Survey flow.

Predictor Variables

Pro-travel attitude was measured with three items from Barr and Prillwitz (2012; e.g., "All people in Germany should have the opportunity to vacation wherever they want in the world"). Due to poor internal consistency, only the named item was used for the analyses. *Environmentally careless holiday attitude* was adapted from pro-environmental holiday attitude introduced by Barr and Prillwitz (2012), yet due to content reasons measured with only one item that we refer to as environmentally careless holiday attitude ("I don't worry about the environment when I make decisions about my vacation travel"). *Perceived behavioral control* [adapted from TPB, Ajzen (1991); "I have enough options for a good vacation without having to fly"] and *efficacy beliefs* [following the operationalization of self-efficacy beliefs from Doran et al. (2015), and considering outcome expectancy from Maddux et al. (1982); "Avoiding air travel helps fighting climate change"] were assessed with one item each.

Global identity was measured with two items (e.g., "Overall, being a citizen of the world is an important part of how I see myself", $r = 0.51^{**}$) selected from Buchan et al. (2011). *National identity* was adapted from Lilli and Diehl (1999), with only two ($r = 0.55^{**}$) out of three items used for the further analyses due to poor internal consistency (e.g., "The nation I belong to is an important reflection of who I am").

Items for assessing *intergenerational justice concerns* were built upon theoretical work from Russell et al. (2003) but shortened to five items and adjusted to the context (e.g., "We should take up all efforts to secure the livelihood of future generations"). Due to poor internal consistency, two items were excluded from further analyses ($\alpha = 0.81$).

Finally, we assessed *subjective knowledge* with one item ["I could spontaneously explain to a friend what air travel has to do with climate change"; Davison et al. (2014)].

Data Analysis

Data was analyzed using IBM SPSS (version 20). Oneway ANOVAs were conducted to test whether the provision of different textual information regarding air travel had an effect on intentions to avoid flights or on policy support. Further, we calculated bivariate correlations (Pearson coefficient), multiple linear regression analyses with step-wise uptake of variables including age, gender, income, education, and subjective knowledge as control variables. In a first step, the predictor variables as well as dummy-coded comparisons between

TABLE 2 | Socio-demographic characteristics of sample and population.

Variable	Classification	Population (in %)	Weighted sample (in %)
Gender	Male	49	48.6
	Female	51	51.1
	Diverse		0.2
Age	16–25	12.5	12.2
	26–35	15.1	15.1
	36–49	20.9	20.6
	50–65	27.9	28.3
	66+	23.6	23.6
Formal education	Still in school	3.3	3.5
	None	3.7	2.2
	Low	30.4	30.2
	Medium	30.2	31.1
	High[a]	32.4	32.8
Income[b]	Less than 1.000€	9.6	12.2
	1.000–1.999€	26.1	27.7
	2.000–2.999€	23.5	27.7
	3.000–3.999€	16.1	16.6
	4.000–4.999€	10.3	9.5
	5.000€ or more	13.6	5.4
City size	Less than 5.000	14.3	14.8
	5.000–19.999	26.5	25.9
	20.000–99.999	27.4	27.5
	100.000 and more	31.8	31.4

Geographical region was representatively distributed in accordance with German states. [a]High formal education is referred to here as university entrance qualification (Abitur, including "Fachhochschulreife"). The population indicators were provided by the market research institute Aproxima with the exception of income. [b]For the income distribution among the German population, data from the Federal Statistical Office (Statistisches Bundesamt, 2020) were used.

TABLE 3 | Average amount of flights differentiated by age and formal education.

Variable	Classification	Mean (number of flights for vacation in the last year)
Age	16–25	1.93
	26–35	1.65
	36–49	1.33
	50–65	1.27
	66+	1.02
Formal education	Still in school	1.89
	None	0.48
	High school diploma (9 years of school)	1.02
	University entrance certificate	1.68
	University degree	1.93

Extreme values >3 SD were removed to minimize the impact of very frequent flyers on the statistics. As stated before, more than two thirds of the respondents indicated to not have taken a plane at all within Europe within the past year for vacation reasons.

experimental conditions and other experimental conditions as well as control condition were included in the regression model. In a second step, we added the interaction terms with global and national identity.

TABLE 4 | Criteria for choice of transport means between 100 and 500 km.

Criterion	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
Travel time	31.4%*	31.2%	22.1%	10.6%	4.6%
Price	33.0%	29.2%	19.4%	13.0%	5.3%
Comfort	16.0%	22.4%	28.9%	20.8%	11.9%
Habit	18.5%	10.5%	14.5%	23.7%	32.9%
Environmental friendliness	6.4%	8.2%	14.8%	29.0%	41.6%

*"What criteria do you use to decide which means of transport you use for your leisure activities for distances between 100 and 500 km? Please rank them accordingly." Rank 1 = most important criterion, rank 5 = lowest importance. *Example: 31.4% of the participants ranked travel time as the most important criterion for choosing their means of transport.*

RESULTS

Bivariate Correlations Between Variables

As displayed in **Table 5**, there was a strong positive correlation between the two outcome variables intention to avoid flights and policy support. Efficacy beliefs, perceived behavioral control to travel without flying, and intergenerational justice concerns revealed moderate or strong positive correlations with the outcome variables. Pro-travel attitude and environmentally careless holiday attitude had moderate negative correlations, global identity had weak positive correlations with both. Among the further assessed (control) variables, age, self-estimated knowledge, and national identity showed weak positive relationships with intentions to avoid flights and policy support. The correlations between the explanatory variables were weak to moderate except for intergenerational justice concern. The latter correlated moderately with efficacy beliefs and global identity.

Predictors of Intentions and Policy Support to Reduce Flights

In a next step, we conducted a multiple linear regression analysis to examine the strength of the relations between the assumed predictor variables and people's intention to avoid flights, controlling for the other predictors as well as the control variables (see **Table 6**). The model explained 43% of the variance in people's intention to avoid flights. The hypotheses that pro-travel attitude and environmentally careless holiday attitude negatively predict intentions were supported. Further, in line with our hypotheses, perceived behavioral control to travel without flying, efficacy beliefs that avoiding flights helps to mitigate climate change, and concern for intergenerational justice positively predicted intentions to refrain from air travel. Perceived behavioral control was the strongest predictor: particularly participants indicating to have sufficient options for traveling without planes had higher intentions to avoid travel. The regression further revealed a small but significant negative relationship between global identity and intentions to avoid flights, contrasting the hypothesized positive relation that was found in the bivariate analysis. Global identity and concern for intergenerational justice were positively related in our study. As justice concerns explained variance in people's intentions to avoid flights, there might be a suppressor effect. In support of this, the negative relation between global identity

TABLE 5 | Bivariate correlations of the predictor variables and outcome measures addressed in this study.

Variable	1	2	3	4	5	6	7	8	9	10	11
1 Intentions to avoid flights	1										
2 Policy support	0.59***	1									
3 Age	0.16***	0.09***	1								
4 Income	–0.04	–0.03	–0.02	1							
5 Pro-travel attitude	–0.30***	–0.32***	–0.07***	0.02	1						
6 Environmentally careless holiday attitude	–0.26***	–0.31***	–0.00	0.06**	0.25***	1					
7 Perceived behavioral control	0.51***	0.38***	0.07**	–0.03	–0.15***	–0.16***	1				
8 Efficacy beliefs	0.46***	0.53***	0.00	–0.02	–0.18***	–0.22***	0.33***	1			
9 Global identity	0.07**	0.17***	0.09***	–0.04	0.02	–0.07**	0.06**	0.16***	1		
10 Intergenerational justice concerns	0.37***	0.50***	0.03	–0.02	–0.16***	–0.28***	0.28***	0.46***	0.41***	1	
11 Subjective knowledge	0.16***	0.28***	–0.06**	0.00	–0.09***	–0.11**	0.15***	0.32***	0.22***	0.31***	1
12 National identity	0.08***	0.08***	0.21***	0.01	0.11***	0.06**	0.09***	0.06**	22***	0.16***	0.04*

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

and intentions vanished (β = -0.01, $p = 0.489$), when we removed intergenerational justice concerns from the model.

Among the control variables, age was positively, and education negatively related to intentions to avoid flights. Income, gender, and subjective knowledge about the impact of air travel for climate change showed no significant association with people's intention to avoid flights.

The second regression model explained 45% of the variance in people's support of policies to reduce air travel (see **Table 7**). Our hypothesis that concern for intergenerational justice is positively related was confirmed. However, contrary to our hypothesis, global identity was not a significant predictor of policy support. Yet, global identity became a positive predictor of policy support (β = 0.08, $p < 0.001$), when we removed intergenerational justice concerns from the model. Among the control variables, age was positively, and high education negatively related to policy support. Furthermore, perceived behavioral control to travel without flying, efficacy beliefs, and subjective knowledge revealed significant positive relationships with policy support, while environmentally careless holiday attitude and pro-travel attitude were negative predictors. Overall, efficacy beliefs and concern for intergenerational justice were the strongest predictors of people's support for restricting flights by political measures. Income and gender were no significant predictors.

Effect of Information on Intentions and Policy Support to Reduce Flights

Comparing the three experimental groups and the control group with oneway ANOVAs revealed that the provision of different textual information regarding air travel had neither an effect on intentions to avoid flights ($p = 0.396$) nor on policy support ($p = 0.296$). Adding three dummy variables for the information conditions (compared to the three other conditions, respectively) in the regression analyses also showed no effects (**Tables 6**, **7**). Interaction terms between information and identity were added in a second step. Disconfirming our hypotheses, neither the interaction between information on (global) inequalities and global identity, nor the interaction between information on subsidies (implying intranational inequalities) and national identity were significant (see **Supplementary Tables 2, 3** for details). Hence, more globally identified people were not more responsive to information including global inequalities, more nationally identified people were not more responsive to information on subsidies implying intranational inequalities. In the regression analysis examining intentions to avoid flights including interaction terms, the experimental condition comprising information on climate impact turned significant ($p = 0.044$), yet with a very small effect size (β = -0.04). As the ANOVA as well as the regression analysis containing the experimental conditions without interaction terms revealed no significant effect of either information condition, we will refrain from further interpreting this (minor) effect.

TABLE 6 | Results of linear multiple regression of intentions to avoid flights.

Predictor	*B*	SE	β	*t*
Age	0.01	0.00	0.11	7.09***
High education (dummy)	–0.35	0.05	–0.11	–6.80***
Pro-travel attitude	–0.20	0.02	–0.17	–9.96***
Environmentally careless holiday attitude	–0.08	0.02	–0.07	–4.20***
Perceived behavioral control	0.43	0.02	0.35	20.30***
Efficacy beliefs	0.30	0.02	0.26	13.59***
Global identity	–0.08	0.03	–0.05	–2.81**
Intergenerational justice concerns	0.30	0.04	0.14	6.84***

Final model. Income, gender, and subjective knowledge were not significant predictors and excluded from the final model. Furthermore, neither information on climate impact (dummy, other experimental groups and control group = 0), information on (global) inequality (dummy, other experimental groups and control group = 0), nor information on subsidies (dummy, other experimental groups and control group = 0) significantly predicted intentions to avoid travel. $R^2_{corr} = 0.43$ *($p < 0.01$). **$p < 0.01$, ***$p < 0.001$.*

TABLE 7 | Results of linear multiple regression of policy support to reduce flights.

Predictor	*B*	SE	β	*t*
Age	0.00	0.00	0.06	3.78***
High education (dummy)	–0.08	0.03	–0.04	–2.47*
Pro-travel attitude	–0.15	0.01	–0.17	–10.23***
Environmentally careless holiday attitude	–0.07	0.01	–0.09	–5.36***
Perceived behavioral control	0.14	0.01	0.17	9.81***
Efficacy beliefs	0.22	0.02	0.29	15.36***
Intergenerational justice concerns	0.37	0.03	0.26	12.92***
Subjective knowledge	0.05	0.01	0.07	3.73***

Final model. Income, gender, and global identity were not significant predictors and excluded from the final model. Furthermore, neither information on climate impact (dummy, other experimental groups and control group = 0), information on (global) inequality (dummy, other experimental groups and control group = 0), nor information on subsidies (dummy, other experimental groups and control group = 0) significantly predicted policy support. $R^2_{corr} = 0.45$ *(p <.001). *p < 0.05, ***p < 0.001.*

DISCUSSION

Summary of the Results and Theoretical Contribution

With this study, we investigated the relationship between pro-travel attitude, environmentally careless holiday attitude, perceived behavioral control to travel without flying, efficacy beliefs, global identity, and concern for intergenerational justice with both, the intentions to avoid air travel as well as policy support to reduce aviation. Moreover, we hypothesized that information on global and intranational inequalities related to air travel will encourage the intention to avoid flights and policy support to reduce air travel—depending on people's identity. Specifically, we expected that globally identified people might respond more strongly to information regarding the global injustice of air travel, while nationally identified people might respond more strongly to information regarding the intranational inequalities induced by subsidies.

Predictors of Intentions to Avoid Flights

In our sample, we found that perceived behavioral control over (sustainable) travel modes, the efficacy belief that avoiding flights helps to mitigate climate change, lower pro-travel attitude, intergenerational justice concerns, age, lower education, lower environmentally careless holiday attitude, and lower global identity predicted intentions to avoid flying in descending order (in terms of strength of the relationship). Subjective knowledge was the only factor not significantly associated with intentions to avoid flying.

The finding that perceived behavioral control to travel without flying was the strongest predictor for intentions to avoid flights is in line with previous research (Dütschke et al., 2022) and in accordance with the TPB that considers perceived behavioral control as a relevant factor explaining planned behavior in general, and pro-environmental behavior in specific (Yuriev et al., 2020). Our results highlight the importance of this factor for pro-environmental behavioral intentions in the mobility sector. Efficacy belief was the second strongest predictor of intentions to avoid flights. Believing that personal behavior makes a difference for the desired outcome (in our case climate change mitigation) thus constitutes another important factor for mobility choices resonating with previous research regarding antecedents of pro-environmental behavior (Doran et al., 2015; Jugert et al., 2016).

Furthermore, the concern for intergenerational justice was positively related to intentions to avoid flights. So far, only few psychological research has dealt with concerns for intergenerational justice. For example, Reese and Jacob (2015) found intergenerational justice to predict pro-environmental intentions independently but indirectly via responsibility and anger. Hence, our findings support and transfer previous results to the concrete topic of flight reduction.

Intentions to avoid flights were higher for participants who consider the environmental impact when planning vacation (negative relation with environmentally careless holiday attitude). People who were convinced that everyone should be able to go on vacation wherever they want showed lower intentions to avoid flights (pro-travel attitude). These findings resonate with prior research (Barr and Prillwitz, 2012). People with such travel attitudes thus might weigh (personal) freedom aspects higher than the environmental impact of traveling.

Furthermore, age was positively related to intentions to avoid flights. Prior research is inconsistent with regard to the relation between age and pro-environmental behaviors (e.g., Wiernik et al., 2013; Otto and Kaiser, 2014). However, our results suggest that avoiding flights is especially unattractive or difficult for younger people who might still have a stronger desire to explore the world. Our results of a negative relation between education and intentions to avoid flights contrast with previous literature showing that the level of education was positively associated with intentions to refrain from air travel (Dütschke et al., 2022). However, the sample of Dütschke et al. (2022) differed from our sample in terms of share of respondents with a university degree. Their sample indicated a higher formal educational status than ours which might explain differences in results. Furthermore, contrary to Reichert and Holz-Rau (2015) but in line with Dütschke et al. (2022), income was not a significant predictor of intentions to avoid flights in our study.

Despite a small positive bivariate correlation with intentions to reduce air travel, global identity negatively predicted intentions to avoid flights in the regression analysis accounting for all other predictors—with a very small effect size. Comparing this result with prior evidence reveals an inconsistent picture. While Römpke et al. (2019) found no association between global identity and personal intentions to reduce flying, Loy et al. (2021) found that people scoring higher on global identity stated to have refrained from air travel more often than less globally identified persons (but this relation vanished when controlling for people's sufficiency orientation). Characteristics of the different samples might be one reason for differing results. Loy et al. (2021) had a sample that was younger and educated above average,

socio-demographic characteristics that come along with higher numbers of flights [Kreil (2021); see also our results]. At the same time, they might be more aware about the negative side effects than the general population. A conflict of interests might arise for highly globally identified individuals. International personal contact, even fictitious one, can strengthen global identification (Römpke et al., 2019). Reversely, such contact might be more important to and aspired by individuals who identify strongly with the world community. Accordingly, Sparkman and Eidelman (2018) found that the number of travels outside the US was positively related with US citizens' global identity. Getting to know other cultures and exploring the world hence potentially constitutes a valuable benefit for these individuals outweighing environmental concerns. Another explanation why global identity was a negative predictor of intentions in the regression analysis (despite a positive bivariate relation) might be that global identity and concern for intergenerational justice were positively related in our study, in line with previous findings (see McFarland et al., 2019). As justice concerns explained variance in people's intentions to avoid flights, there might be a suppressor effect. In support of this, the negative relation between global identity and intentions vanished, when we removed intergenerational justice concerns from the model.

Predictors of Policy Support to Reduce Flights

When regressing policy support to reduce air travel on the examined predictor variables, we found that efficacy beliefs that reduced aviation helps to mitigate climate change and intergenerational justice concerns were the strongest predictors, followed by perceived behavioral control to travel without flying, and a weaker pro-travel attitude. Low environmentally careless holiday attitude, subjective knowledge, age, and low education predicted policy support significantly but with weaker relationships. Global identity was not a significant predictor.

The positive relation between perceived efficacy of avoiding air travel as means to mitigate climate change and policy support resonates with similar findings that the perceived effectiveness of concrete policy measures predicts their support (Bergquist et al., 2022). Even though we asked about the effectiveness of the behavior change *per se* instead of policies encouraging this behavior change, it makes sense that perceiving the target behavior of policies to be an effective means to achieve a desired goal (in this case climate mitigation) facilitates policy support.

Previous research has further demonstrated that the perceived fairness of policies is a particularly strong correlate of policy acceptance (Bergquist et al., 2022). Fairness perception, in turn, might depend on justice concerns. This might be reflected in our result that concerns about justice, in this case intergenerational justice, were positively related to policy support in favor of reducing unfair climate impacts for future generations (even though we did not concretely ask about the fairness of policies from an intergenerational perspective).

Perceived behavioral control to travel without planes predicted policy support positively. It could be argued that people feel less personally affected by newly introduced restrictions of air travel if they believe to have sufficient alternatives and hence show higher support for these policies. This would support previous studies demonstrating a negative influence of perceived intrusiveness, namely personal costs, on support for policies (Huber et al., 2020). Unsurprisingly, people who agreed that everybody should be able to vacation wherever they want to in the world (pro-travel attitude) showed lower support for policies that aim at reducing air travel as this might restrict the possibility to reach certain remote destinations.

Despite a small positive bivariate correlation between global identity and policy support, this relation vanished when controlling for the other predictors in the regression model. This contrasts with the study by Loy et al. (2021). As argued for behavioral intentions, conflicting interests between international travel desires and environmental concerns could again play a role. Global identity became a positive predictor of policy support, when we removed intergenerational justice concerns from the model.

To summarize, perceived behavioral control to travel without flying and efficacy beliefs that reducing flights contributes to climate protection were the most relevant predictors of both, intentions and policy support to reduce flights. Moreover, a concern for intergenerational justice might motivate people to find alternatives for flying and to support aviation-related environmental policies.

Effect of Information on Intentions to Avoid Flights and Policy Support

Air travel is a domain highly intertwined with justice-related questions—from a global, intranational, and intergenerational point of view. Knowledge about environmental problems and related injustices (e.g., coming along with standards of living, specifically in the Global North) is considered a prerequisite for environmental action to be initiated (Frick et al., 2004; Jacobson et al., 2020). Thus, we tested whether providing additional information on environmental impacts and different inequalities linked to air travel influenced intentions to avoid flights and policy support to reduce air travel. We compared three types of information with a control group not receiving information: climate impact, global and intranational inequalities, and subsidies (implying intranational inequalities). We hypothesized that information on subsidies implying intranational inequalities might be particularly engaging for people with a strong national identity, while people with a strong global identity might be particularly receptive to information on not only intranational but also global inequalities.

None of the three information texts had an impact on intentions to avoid flights and policy support. In addition, we found neither an interaction effect between information on global inequality and global identity, nor between subsidies (implying intranational inequalities) and national identity. In sum, merely providing information on climate and justice-related aspects of air travel did not have an effect in our sample, neither on the individual behavioral dimension nor on policy support.

This finding resonates with psychological research that providing information tends to have only small effects if at all as long as it is not combined with, for example, action-enabling information (Frick et al., 2004). Moreover, the overall awareness of our sample might have already been quite high due to the

public attention regarding problems of air travel raised by the Fridays for Future movement. Providing additional information might therefore not motivate engagement (anymore). Yet, it was surprising to us that especially global identity did not interact with the content of the textual information.

Use and Attractiveness of Different Long-Distance Transport Modes

According to our data, there seems to be a basic awareness and attention of the population to the connection between climate change and air travel (represented in subjective knowledge). Our data reveal that only a small part of the respondents fly on a regular basis. More than half of our respondents did not fly at all in the past year, at least within Europe. This finding is in line with other studies (Gössling and Humpe, 2020; Dütschke et al., 2022). Yet, travel time and price were the two criteria ranked as most important for choosing transport means among the majority of our respondents, whereas almost half ranked environmental friendliness last. Hence, the (infrastructural) availability and a subjectively positive evaluation of alternatives (e.g., in terms of travel time and price) could contribute to the promotion of sufficiency-oriented mobility. In terms of travel time, night trains might constitute a practical approach for traveling longer distances within Europe. This is supported by our finding that night trains were generally evaluated as an attractive form of travel but only some of the respondents had used them so far. A majority would like to see an increase in the number of night trains.

Limitations and Future Research Directions

Several limitations of this research need to be discussed. First, most results are correlational and no conclusions on causality of the bivariate relationships between variables can be drawn. Future research should thus develop longitudinal and/or experimental designs to better establish the direction of possible effects.

Second, the operationalization of the assessed variables could be improved. Some scales were lacking internal consistency (e.g., pro-travel attitude). Furthermore, we used several one-item measures for reasons of practicality and questionnaire brevity. More extensive (pre-tested) scales would increase reliability and validity of the measurement. Concern for intergenerational justice was a central component of this study. As we did not find a tested scale, we developed items *ad hoc* based on theoretical considerations by Russell et al. (2003). Future work could take a step back and develop and validate a profound theoretically based scale. Still, internal consistency of our items was high after removing two items.

Third, there are several other factors that explain pro-environmental behavior (Bamberg and Möser, 2007; Klöckner, 2013). Specifically, social and personal norms might be relevant, even though, as described, research revealed mixed evidence for air-travel related behavior (Davison et al., 2014; Dütschke et al., 2022). Still, future studies could include them and help to disentangle inconsistencies.

Despite these limitations, our study also holds several strengths. First, while previous studies used rather selective samples (e.g., Loy et al., 2021), our results were generated with a heterogeneous sample mirroring diverse segments of the German population.

Second, air travel is a highly relevant individual behavior in terms of its climate impact which has received minor attention in environmental psychology research. Our study thus contributes to the little initial knowledge about people's motivation to refrain from flying (Loy et al., 2021; Oswald and Ernst, 2021; Dütschke et al., 2022).

Third, concern for intergenerational justice has not received much attention in psychological research but seems especially relevant due to the long-term consequences of climate change for future generations. For example, research by Hauser et al. (2014) showed that people are willing to avoid overexploitation of resources for the benefit of future generations when resource use is democratically determined by vote. Syme et al. (2000) argued that perceiving intergenerational injustice impacts pro-environmental political compliance. Furthermore, Reese and Jacob (2015) found that valuing intergenerational justice of resource use was related to people's intentions to act pro-environmentally. Our study adds the relevance of people's concern for intergenerational justice for decision making in the context of air-traveling. Future research could examine how concerns for intergenerational justice emerge. For example, one could assume that having a child might induce parents to care more for environmental protection. Even though Milfont et al. (2020) found no relation between parenthood and environmental concern or changes in routines and standard of living, parents might constitute a suitable target group responsive for interventions that address the future state of the planet as basis for enabling well-being of their children. Future research could test whether experimentally evoked salience of intergenerational injustices of climate change leads to different outcomes for parents compared to childless adults.

Only a small share of the population takes planes on a regular basis and their environmental impact is outstandingly high. Future studies could thus focus specifically on frequent flyers, examining factors that explain the high frequency of taking planes. It would be particularly interesting to understand how injustices from which this group benefits are perceived by them. Moreover, other variables potentially explaining the intention to avoid flights might be further investigated. For example, the symbolic and social value of air travel could be examined as individual behavior is intertwined with and guided by social structures (O'Connor, 2015; Windsor, 2018; Nguyen-Van et al., 2021). Further research could also consider people in their political actions. Aviation-related public sphere behaviors like engaging in movements that promote alternative traveling styles could be analyzed. Public sphere behavior and niche movements can contribute to changing the mobility system and its regulative and economic frame (Geels, 2004).

Resonating with prior research on the relation between justice concerns and global identity (Reese et al., 2014), in our study, concern for intergenerational justice was correlated with global identity. This implies that people who identified themselves more with the world community also showed higher concerns for intergenerational justice than individuals with lower global identification. However, we only found weak correlations of

global identity with intentions and policy support to reduce air travel. These relations turned insignificant when considering further predictors in the regression models. In case of behavioral intentions, global identity even became a negative predictor, even though the effect size was very small. Therefore, future research could dive deeper into examining potentially conflicting norms and values of individuals with high global identity in terms of flying.

People's perceived behavioral control to be able to travel without planes and their efficacy beliefs to thereby contribute to climate protection were the strongest predictors of intentions and policy support to reduce air travel in our study. Therefore, future research should investigate ways to foster these control beliefs. In particular, we deem it interesting how structural changes (e.g., improvement of the train infrastructure, lower prices of sustainable mobility options) would impact people's perception that giving up flights is possible.

Practical Implications

In addition to a general reduction in (long-distance) travel, switching to (night) trains, especially for travel within Europe, constitutes a relevant way of reducing emissions. The existence of alternatives and the associated perception of control over (sustainable) travel options are central to promoting sustainable mobility. With this study, we demonstrated that the more people perceive to have enough alternatives for vacation without flying and that avoiding air travel helps mitigate climate change, the more they support aviation-regulating policy measures as well as individually intend to refrain from flying. This finding supports claims from environmental organizations and civil society (see e.g., Stay Grounded[1]) that expanding infrastructure for climate friendly alternatives, such as railway or cycling routes, and ceasing subsidies for carbon-intensive transport means can contribute to reducing air travel. A majority of our participants opted for an increase in night trains but there are other reasons besides availability that can be addressed to provide an attractive alternative travel option to air travel in the future (e.g., cost of tickets). In addition, opportunities could be given to encourage people to try out night trains and thereby gain experience (e.g., taster offers). In summary, (night) trains can make a decisive contribution to reducing emissions in transport, as both travel by car and by air can be substituted. By creating suitable framework conditions and infrastructure, this form of sufficiency-oriented mobility behavior can be promoted.

Traveling seems to have many advantages—among them possibilities for individual growth and personality development through international exchange (e.g., Phillips, 2019). However, there might be ways of becoming aware of other cultures and develop openness toward others without traveling by plane. As frequency and quality of contact with people during journeys might be more important than being frequently abroad *per se* (Loy et al., 2021), slow travel modes might be similarly or even better suitable. Showing opportunities for traveling on the ground (e.g., terran[2]) and setting an example for environmentally friendly travel behavior might establish new travel norms particularly for young people who have not yet become used to flying.

CONCLUSION

Concerted, timely action is of uttermost importance for mitigating climate change. Air traffic already plays a strong role in driving climate change and is projected to grow—with only limited technical potential for decarbonizing this means of transport. Therefore, it is desirable to minimize the expansion of air traffic or even facilitate a reduction in affluent countries. Effective policies and behavioral change, especially among frequent flyers, can help to lower greenhouse gas emissions. For both, a positive evaluation and public support are indispensable.

We contribute to understanding people's intentions and policy support to reduce air traveling and found that three aspects were most important in our sample: perceived behavioral control to travel without flying, beliefs in positive outcomes of flight avoidance, and intergenerational justice concerns. Therefore, we conclude that the mobility sector should facilitate attractive and accessible transport alternatives to planes. Moreover, the value of intergenerational justice needs to be conveyed in order to motivate people to reduce aviation as means to foster a livable future for new generations.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: http://dx.doi.org/10.24406/fordatis/69.

AUTHOR CONTRIBUTIONS

JB conceptualized and designed the study, conducted the analysis, and interpreted the data. JB drafted the introduction, methods, results and the discussion section, and contributed to the theoretical background. AB contributed to the analysis and interpretation of the data. AB wrote parts of the theoretical background and discussion. LL contributed to the interpretation of the data and wrote parts of the introduction, theoretical background, results and discussion. All authors contributed to the manuscript revision, read, and approved the submitted version.

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[1] https://stay-grounded.org/

[2] https://terran.eco/en/

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Climate change opportunities reduce farmers' risk perception: Extension of the value-belief-norm theory in the context of Finnish agriculture

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Global agriculture faces severe challenges due to climate change. For boreal agriculture, climate change might also bring opportunities as the growing season lengthens, if the risks of climate change are managed properly. Agricultural production is a source of greenhouse gases, while agricultural land has also a great possibility to mitigate climate change as a carbon sink. Farmers are the central group for implementing these actions. Their views and beliefs contribute to their corresponding pro-environmental agricultural behavior. This research is based on the theory of value-belief-norm (VBN) as a predictive model of pro-environmental agricultural behavior. We extend the theory by studying how opportunities caused by climate change affect pro-environmental behavior in agriculture and present differences between farmer groups and experiment with the longitudinal possibilities of the theoretical model. Based on the structured survey responses from 4,401 farmers in Finland in 2018 and 2000 responses in 2020, we found that all the elements of VBN theory did help to predict intention for climate change mitigation, among which felt possibility to perform mitigation practices was the strongest predictor while risk perception was rather an unimportant one. Furthermore, opportunities caused directly or indirectly by climate change have an effect on Finnish farmer's implementation of mitigation practices. Therefore, future efforts in agricultural research and policy in Finland should concentrate to bring forth concrete farm-level mitigation practices with proven environmental benefits and the direct and indirect opportunities should be given more attention.

KEYWORDS

climate change, opportunity, farmer, agriculture, value-belief-norm theory, survey, Finland

Introduction

Strong scientific proof supports anthropogenic climate change and shows that the pace of change has accelerated. Mitigation actions have not yet been able to curb emission trends globally (IPCC, 2021). Agriculture constitutes around 10% of the greenhouse gas (GHG) emissions in Europe without land use, land use change, and forestry (LULUCF) sector emissions; when these are included, agricultural emissions are around 20% of Europe's total emissions (EEA, 2019; YM, 2021). In Finland, the agricultural GHG emissions follow the Europe's average. The Finnish government has committed to reduce agricultural-related emissions by 29% by 2035 (MMM, 2022).

Climate change brings challenges to Finnish agriculture (Hakala et al., 2011; Tao et al., 2020). New crop diseases and pests and their earlier occurrence can be expected (Peltonen-Sainio and Jauhiainen, 2020). The increased frequency of extreme weather conditions, such as increased precipitation, heavy rainfall (Peltonen-Sainio et al., 2021), and drought, further challenges field drainage and water retention (Peltonen-Sainio et al., 2016). More frequent drought and heat stress with other environment-related constraints may lead to higher yield variability and yield loss (Purola et al., 2017). Climate change may also challenge both nutrient and carbon cycles because warming may speed up both the production and decomposing of organic matter. In addition, changes in the water cycle impact on the leaching of organic matter and nutrients from soil to water (MMM, 2014).

While the negative impacts of climate change are already felt globally (Gammans et al., 2017; Cianconi et al., 2020; IPCC, 2022), the northward shift of warmer climate might create opportunities for the boreal region as to their suitability for agriculture in terms of new species and potential yield increase (King et al., 2018; Unc et al., 2021). These opportunities are also applicable to Finland (Peltonen-Sainio et al., 2018, 2020) and are recognized by the farmers (Sorvali et al., 2021). Even if high-latitude agriculture may benefit from climate change, it still needs to contribute to reduction of GHG emissions as defined in national and international climate policies and agreements. Naturally, farmers are the central group for implementing these climate actions at the farm level (Gomes and Reidsma, 2021).

Farmers' engagement in climate change mitigation requires awareness of climate change (Arbuckle et al., 2013a), and personal values have also been found to play a role (Sorvali et al., 2022). Finnish farmers have a very high awareness of climate change, but they have differing views on the balance of risks and opportunities, although especially opportunities are highly recognized. Similarly, farmers' views on their responsibilities to act as do their perception of own possibilities to adapt and mitigate differ in different farmer groups (Sorvali et al., 2021). Finnish farmers are, in general terms, strongly inclined toward self-transcendence values and universalism values (Sorvali et al., 2022), which are especially connected to pro-environmental concerns (Hansla et al., 2008).

Without understanding the farmers' values, beliefs, and normative views, it is impossible to draft policy measures that will be accepted and thoroughly implemented by farmers. In this article, we extend the study of Sorvali et al. (2021, 2022) and apply the theory of value-belief-norm (VBN) (Stern, 2000) to deepen the knowledge of Finnish farmers pro-environmental behavior. We contribute to previous psychological literature by bringing in perceived opportunities caused by climate change as a new predictive element. Furthermore, we aim to compare the results between different farmer groups and between two spaces in time (2018 and 2020). Thus, we directly contribute to the VBN theory with the new element of opportunity and longitudinal data in which the participants were identical.

The rest of the chapters are organized as follows: Chapter two gives a short overview of the VBN theory, the terminology, and an overview of previous research with specific emphasis on agriculture. In chapter three, materials and methods are described, and chapter four presents the results. The findings are being discussed in chapter five together with limitations of the research and suggestions for future research and concluding remarks are presented in chapter six.

VBN and its applications in pro-environmental behavior

Theory of value-belief-norm (VBN) (Stern, 2000) conceptualizes how certain values, pro-environmental worldview (NEP), understanding of the consequences of environmental problems (AC) together with perceived ability to reduce threat (AR), and personal norms (PN) explain pro-environmental behavior. The VBN theory is based on the basic human values (Schwartz, 1992), the Norm-Activation Model (NAM) (Schwartz, 1977; Schwartz and Howard, 1981), and the New Environmental Paradigm (NEP) (Dunlap and Van Liere, 1978) theories. As VBN theory or parts of it has widely been used in studying environmental behaviors in different contexts by scholars from differing backgrounds, the terminology has become incoherent and sometimes difficult to follow. Thus, an effort is made here to connect the original VBN terminology to the terminology used in similar fashion in different contexts and simplify the terminology (Figure 1).

Values are "desirable trans-situational goals, varying in importance, that serve as guiding principles in the life of a person or other social entity" (Rokeach, 1973; Schwartz, 1994). Values have been thoroughly studied in the literature concerning environmental behavior, and especially self-transcendence values (universalism and benevolence) have been related to high environmental concern (Stern, 2000; Schultz et al., 2005; Hansla et al., 2008). The connection between values and behavior has been widely debated, but it is commonly accepted that values

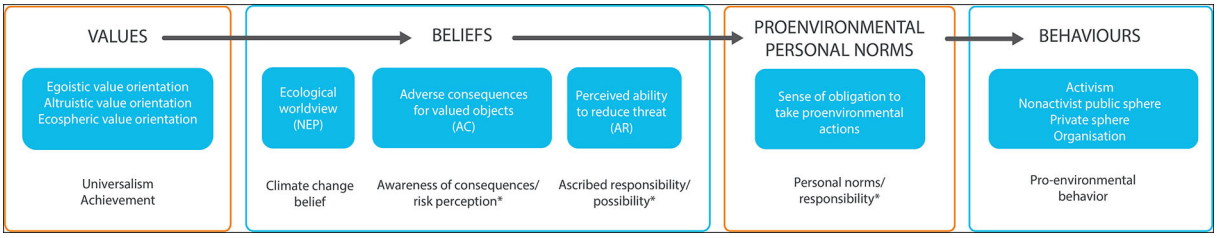

FIGURE 1
Original VBN theory (Stern, 2000) is shown in blue boxes. Under the boxes, corresponding terms are used in literature. Terms marked in asterisk are used in this research.

predict different attitudes and behaviors (Sagiv et al., 2017). Research on farmers' values has also gained attention in recent years, and self-transcendence values have been found to score high among farmers in different countries (Dobricki, 2011; Baur et al., 2016; Sorvali et al., 2022).

A *belief* is one's personal knowledge on how things are. A belief can be scientifically correct or incorrect. What is important is that person believes it to be true (Heberlein, 2012). Farmers' beliefs connected with the human–environment interaction in the climate change context have been the growing focus of research in the past decade (Karki et al., 2020) with many examples around the world (USA: Arbuckle et al., 2013a,b; Australia: Buys et al., 2012; Chile: Roco et al., 2015; New Zealand: Niles et al., 2016; Italy: Nguyen et al., 2016; Sweden: Asplund, 2016; South Africa: Hitayezu et al., 2017; Bangladesh: Kabir et al., 2017; Nepal: Khanal et al., 2018; Norway: Brobakk, 2018; Peru: Altea, 2020 and Finland: Peltonen-Sainio et al., 2020; Sorvali et al., 2021). Perception is sometimes used interchangeably with attitude or belief, but it is a broader term incorporating knowledge, beliefs, attitude, concern, affect, and perceived risk (Whitmarsh and Capstick, 2018).

Awareness of adverse consequences for valued objects (awareness of consequences) essentially means belief that environmental conditions, such as climate change, threaten something that the individual values (Steg et al., 2005). In literature, *risk perception* has been used interchangeably with awareness of consequences (e.g., Arbuckle et al., 2015), and it has been identified in many studies as important predictor of pro-environmental action (Zheng et al., 2020; Maartensson and Loi, 2022). Risk is a situation, event, or activity which might lead to uncertain and adverse outcomes toward something of value (Böhm and Tanner, 2019). According to IPCC (2018), climate change risk "refers to the potential for adverse consequences of a climate-related hazard, or of adaptation or mitigation responses to such a hazard, on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure". Thus, risk perception refers to the subjective judgment of people about those climate change risks (IPCC, 2018). Risk perceptions of climate change vary internationally (Lee et al., 2015) and change over time (Milfont et al., 2017). Farmers' climate change-related risk perceptions in differing geo-political and climate conditions have been a rising area of interest for research during recent years (Niles, Lubell and Haden, 2013; Eitzinger et al., 2018).

Perceived ability to reduce threat, or more simply, felt *possibility* to perform pro-environmental behavior that will, in our case, reduce the effects of climate change, is related to self-efficacy that means "a judgment of one's capability to accomplish a certain level of performance" (Bandura, 1986). Social norms are behavioral regularities, or rules and standards, that come with sanctions if they are not followed (Heberlein, 2012; Keizer and Schultz, 2019). *Personal norms* are rules or standards for one's own behavior (Kallgren et al., 2000). Any behavior that has an impact on the environment is considered environmental behavior (Gatersleben, 2019). *Pro-environmental behavior* (or environmentally friendly; ecological; conservation behavior) can be defined as either goal-directed: "behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world". (Kollmuss and Agyeman, 2002), or non-goal-directed: "behavior that harms the environment as little as possible or even benefits the environment" (Steg and Vlek, 2009).

The VBN theory has been widely used to explain pro-environmental behavior in different contexts, such as in sustainable consumption (Han et al., 2020; Yakut, 2021; Ahn and Kwon, 2022), sustainable tourism (Han, 2015, 2021; Manosuthi et al., 2020; Sharma and Gupta, 2020), sustainable management of protected marine areas (Wynveen et al., 2015), and different geographical and ethnic contexts (Chen, 2015; Ghazali et al., 2019; Medina et al., 2019). Although thorough VBN applications for agriculture are still few in numbers, the separate VBN elements have been included in many studies in the agricultural sector, for example, connections between climate change beliefs to adaptation and mitigation action in Denmark (Jørgensen and Termansen, 2016), and climate change beliefs and norms in Scotland (Barnes and Toma, 2012) and Germany (Eggers et al., 2015; Jantke et al., 2020). From the

more thorough applications of the VBN theory in agriculture, Price and Leviston (2014) found that Australian farmers' context and social-psychological characteristics predict their pro-environmental land management practice, further validating arguments that agricultural change is driven by individual motivations. Sanderson et al. (2018) draw upon the VBN theory and the result indicated that value-based engagement strategies could provide significant leverage to increase public participation regardless of farming or non-farming participating groups. With the VBN framework, Rezaei-Moghaddam et al. (2020) analyzed Iranian farmers' pro-environmental behaviors concerning the adoption of clean technology of local compost. The results found that strong responsibility for nature increases adoption of the pro-environmental behavior. Zhang et al. (2020) compare the predictive power of the VBN theory with the Theory of Planned Behavior (TPB) in the context of climate change mitigation and adaptation in China. The study provided evidence that the VBN theory performed better when explaining mitigation behaviors of Chinese farmers.

Climate change opportunities are defined here as direct opportunities caused by global warming (e.g., possibility to extend agricultural production to more northern areas because of the rise in average temperatures) and as indirect opportunities where an action becomes beneficial because of the need to adapt or to mitigate climate change (e.g., development of new technology). According to Finnish farmers, climate change will bring opportunities for agriculture through, for example, longer growing seasons and bigger yields. Moreover, the farmers' perception of opportunities has grown during the years (Sorvali et al., 2021). Sorvali et al. (2021) also suggest that farmers who believe strongly in climate change opportunities also believe in their possibilities to adapt to future conditions and do not feel responsible for mitigation. As Finnish farmers' value profiles (Sorvali et al., 2022) and climate perceptions vary significantly between different groups (most notable differences were found between genders, age groups, and farming systems) (Sorvali et al., 2021), the connections and their impacts to pro-environmental behavior, such as mitigation willingness, needed more thorough studying. Research on climate change opportunities is scarce, and the psychological effects of existing climate change opportunities to pro-environmental behavior have not been studied at all.

Therefore, our hypotheses are (1) the VBN theory elements form a causal path from pro-environmental value of universalism *via* climate change belief, risk perception, felt possibility to mitigate, and felt responsibility to mitigate to pro-environmental behavior as suggested by Stern (2000), (2) opportunities have negative direct effect to risk perception and felt responsibility to mitigate climate change and pro-environmental behavior based on previous research by Sorvali et al. (2021), and (3) different elements of the VBN theory are highlighted in different farmer groups: gender (men/women), age (under 40/40 years or older), and farming method (organic/conventional) and at different years (2018 and 2020) as suggested in Sorvali et al. (2021, 2022).

Materials and methods

A standardized survey was sent *via* e-mail in 2018 to all Finnish farmers. The participants were asked to answer over 200 structured statements concerning their climate change beliefs, and their views on adaptation and mitigation practices in agriculture (described in detail in Peltonen-Sainio et al., 2020; Sorvali et al., 2021). Values and future views were also asked. A follow-up survey was sent in 2020 to those who answered the first survey. In 2018, 4,401 farmers answered the survey (12% of all the Finnish farmers with an available e-mail address and 9% of all the farmers in Finland), and in 2020, 2,000 farmers (45%) answered the follow-up survey. The respondents represented the Finnish farming community well (see detailed descriptions of the respondents in Appendix 1). The basic data used here are the 2020 survey data, but differences to the corresponding statements in 2018 are also studied.

Farmers' values were studied using the refined Theory of Basic Human Values by Schwartz et al. (2012). The original theory of Basic Human Values was based on the idea of 10 basic values that form a circular continuum of motivations (Schwartz, 1992). Later, the theory was refined to comprise 19 basic values (Schwartz et al., 2012). Finnish farmers' values and the methodology used are reported in Sorvali et al. (2022). In the original VBN theory, an earlier version of the Schwartz value scale is used, where biospheric values correspond to universalism values, altruistic values to benevolence values, and egoistic values to hedonism. Universalism has the strongest positive connection to the other VBN elements and achievement to the climate change opportunities (Sorvali et al., 2022) and was therefore included in this study. Values were measured only in the 2018 survey, but as values stay relatively stable over time (Sagiv et al., 2017) and the same respondents were studied in both 2018 and 2020 surveys, it was safe to use the 2018 measured values also in the 2020 data analysis.

Instead of the NEP scale that measures general environmental attitudes and is used in the original VBN theory, a more climate change-specific measure was needed. Thus, climate change belief was used and it was measured by a scale differentiating between anthropogenic climate change and climate change caused by nature's own processes (Arbuckle et al., 2015). Risk perception was measured with a single statement relating to the climate change risks to Finnish agriculture. Climate change opportunities were measured with six statements covering different levels of agricultural actors in Finland and possibility to influence mitigation with five statements. Felt responsibility for mitigation was measured with two statements and pro-environmental behavior with one statement about the farmer's intended mitigation action.

Although criticism has been presented against studying intention as a prediction for actual behavior also in the agricultural setting (Niles et al., 2016), for this research, the measures for actual mitigation behavior were not possible to obtain as there are no sufficient documented data on mitigation action undertaken by farmers in Finland. Statements and response scales are presented in Appendix 2, and correlations and other statistical variables are presented in Table 1. Pro-environmental behavior was not asked similarly in the 2018 survey and therefore also not reported here.

The path model was selected for analyzing the relations between the sum variables formed, allowing to test all the direct and indirect effects of the variables simultaneously. Spearman's rho was applied to test correlations between the variables because half of the variables were measured in ordinal scale. The internal consistency of the sum variables was tested using Cronbach's alpha and was found acceptable in all cases. The same theory-based path model was fitted also for different farmer groups according to gender (men/women), age (under 40/40 years or older), and farming method (organic/conventional). The models for 2 years (2018/2020) were also compared, although the answers for one statement concerning pro-environmental behavior were not gathered for both years.

Despite a few ordinal scale variables, large sample size and normally distributed variables enabled the use of maximum likelihood (ML) estimation. Modification indices, such as Lagrange's multiplier test, were used to evaluate the models, but only in one case, a new significant relation that improved the model was included. Goodness-of-fit models were evaluated by three different criteria and the chi-square test, which, however, are known to be problematic with large samples (Vandenberg, 2006). The indices used to assess model fit were the root mean square error of approximation (RMSEA) and the standardized root mean square residual (SRMR), in which values below 0.08 can be considered a reasonable fit and RMSEA ≤ 0.05 a good fit. In addition, we used the comparative fit index (CFI), in which values >0.90 can be considered as a reasonable fit and values over 0.95 a good fit (Hu and Bentler, 1999). SAS Enterprise Guide 7.15 (SAS Institute, Inc., Cary, NC, USA) was used in the statistical analyses.

Results

The base model for all farmers in 2020

The model fit for *year 2020* was good according to the indices (CFI = 0.998; RMSEA = 0.028; and SRMR = 0.011) (Figure 2). All the relations were statistically significant, except the paths from achievement to responsibility and to pro-environmental behavior, from opportunity to responsibility, and from risk perception to pro-environmental behavior (Figure 2; Table 2).

TABLE 1 Spearman's correlations, means, standard deviations, skewness, and kurtosis of the variables for climate change belief, risk perception, opportunity, possibility, personal norms, pro-environmental behavior, achievement, and universalism values used in path models.

	Achievement	Universalism	Climate belief	Opportunity	Risk perception	Possibility	Responsibility	Pro-environmental behavior
Achievement	1	0.527	***	***	**	0.425	0.055	0.085
Universalism	−0.01	1	***	0.052	***	***	***	***
Climate belief	−0.10	0.28	1	***	***	***	***	***
Opportunity	0.16	−0.04	−0.11	1	***	***	0.871	0.376
Risk perception	−0.06	0.15	0.29	−0.37	1	***	***	***
Possibility	0.02	0.31	0.39	0.10	0.21	1	***	***
Responsibility	−0.04	0.29	0.38	0.00	0.24	0.47	1	***
Pro-environmental behavior	−0.04	0.27	0.37	−0.02	0.15	0.48	0.38	1
Mean	3.49	4.38	4.06	3.25	2.99	3.46	3.38	2.32
SD	0.92	0.81	0.78	0.7	1	0.85	0.58	0.63
Skewness	−0.07	−0.5	−0.68	−0.18	0.04	−0.54	−0.04	−0.36
Kurtosis	−0.14	0.6	0.78	0.64	−0.33	0.39	0.04	−0.68
Cronbach's α	0.64	0.87	-	0.8	-	0.75	0.76	-

Statistical significance (H_0:|r|=0): $^{**}p < 0.01$, and $^{***}p < 0.001$.

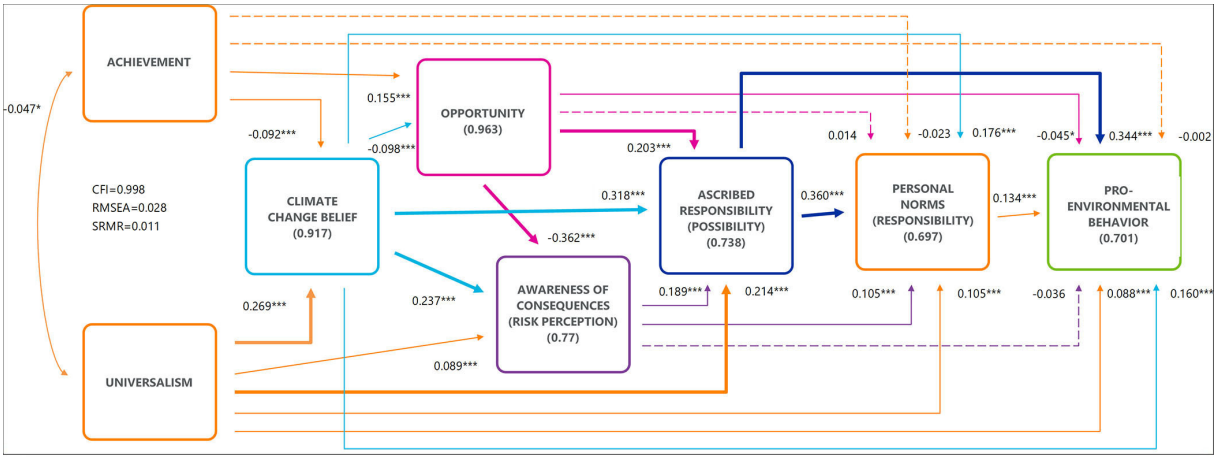

FIGURE 2
Path model for all farmers in 2020 (The base model, $N = 1{,}965$). The value on the double-headed arrow is the correlation coefficient, single-headed arrows are the standardized regression coefficients, and the values in parentheses are the standardized error variances. All the parameters of relations described by solid lines differed from zero, and the relations described by dashed lines were not statistically significant. Three goodness-of-fit indices are shown in the left: CFI, comparative fit index; CI, confidence interval; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual. Statistical significance (H0:|r|=0): * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$.

These connections were, however, left into the model because of the aim to study how opportunity affects the models.

The *values* of universalism and achievement correlated negatively ($\beta = -0.047^{*}$) with each other in accordance with the basic human values theory. As hypothesized, *universalism* had a statistically significant direct effect to risk perception ($\beta = 0.089^{***}$), but 45% of its effect was mediated *via* belief of climate change to risk perception (Appendix 3).

Universalism had also a direct effect to possibility to mitigate climate emissions ($\beta = 0.214^{***}$), but again, 34% of its effect was mediated *via* climate change belief, opportunity, and risk perception. Universalism affected directly also responsibility for mitigation ($\beta = 0.105^{***}$) and the pro-environmental behavior ($\beta = 0.088^{***}$), with indirect effects at 63 and 68%, respectively. *Achievement* had a negative effect to climate change belief ($\beta = -0.092^{***}$), indicating that higher achievement score led to a more questionable belief of the anthropogenic origin of climate change. A positive direct effect from achievement to opportunity was found ($\beta = 0.155^{***}$), and only 6% of the total effect was mediated *via* climate change belief.

Climate change belief had a positive direct effect to felt responsibility of mitigation ($\beta = 0.176^{***}$) and to pro-environmental behavior ($\beta = 0.160^{***}$). *Opportunity* had a strong negative connection to risk perception ($\beta = -0.362^{***}$), indicating that climate change opportunities reduce the notion of risk caused by climate change to agriculture. On the contrary, opportunity was positively connected to possibility to mitigate climate change ($\beta = 0.203^{***}$). Opportunity had also a negative direct effect to pro-environmental behavior ($\beta = -0.045^{*}$) that can be understood as unwillingness to mitigate something that will seemingly bring benefits. *Risk perception* had direct effects to mitigation possibility ($\beta = 0.189^{***}$) and to responsibility of mitigation ($\beta = 0.105^{***}$), but surprisingly not to intended action. Felt *possibility* to mitigate had strong direct effects to *responsibility* ($\beta = 0.360^{***}$) and to *pro-environmental behavior* ($\beta = 0.344^{***}$), indicating that felt responsibility mediated only 12% of the effect of felt possibility to pro-environmental behavior.

Models for different farmer groups

The path models for different farmer groups showed also good or at least acceptable fit. The standardized regression coefficients for each farmer group are presented in Table 2, and the biggest differences are described below. The model for *men* showed no significant differences to the base model for 2020. The models for *farmers 40 years or older* and for *conventional farmers* were also similar as the base model (see Table 2). This was because male, 40 or older, and conventional farmer respondents formed such a large part of the whole sample (89, 82, and 84%, respectively) (Appendix 1). The model for *all farmers 2018* did not include the variable of pro-environmental behavior, as it was not included in the first survey. The relation from climate change belief to opportunity lost its statistical significance in the 2018 model compared to the 2020 one, but otherwise significant differences were not found.

In the model for *women,* two relations (from achievement to responsibility and from opportunity to pro-environmental behavior) turned from negative to positive compared to the base model, although these relations were no longer

TABLE 2 Path model results for all farmers in 2020 (The base model, $N = 1{,}965$), women 2020 ($N = 217$), men 2020 ($N = 1{,}748$), farmers under 40 years old ($N = 356$), farmers 40 years old or older ($N = 1{,}609$), organic farmers ($N = 239$), conventional farmers ($N = 1{,}694$), and all farmers in 2018 ($N = 1{,}965$).

		Estimates							
Variable	**Predictor**	**All 2020**	**Women**	**Men**	**Under 40**	**40 or over**	**Organic**	**Conventional**	**All 2018**
Climate belief	Achievement	−0.092***	−0.087	−0.088**	−0.025	−0.108***	−0.051	−0.092***	−0.079***
Climate belief	Universalism	**0.269*** **	0.179**	**0.267*** **	**0.336*** **	**0.250*** **	**0.457*** **	**0.233*** **	0.270***
Opportunity	Achievement	0.155***	0.041	0.163***	0.198***	0.151***	0.187**	0.153***	0.160***
Opportunity	Climate belief	−0.098***	**−0.212****	−0.074**	−0.135**	−0.091**	−0.118°	−0.089***	−0.024
Risk perception	Climate belief	**0.237*** **	0.137*	**0.246*** **	**0.286*** **	**0.224*** **	**0.224*** **	**0.236*** **	**0.274*** **
Risk perception	Universalism	0.089***	0.040	0.085**	0.135**	0.078**	0.176**	0.073***	0.090***
Risk perception	Opportunity	**−0.362*****	**−0.424*****	**−0.351*****	**−0.305*****	**−0.375*****	**−0.310*****	**−0.368*****	**−0.336*****
Possibility	Opportunity	**0.203*** **	0.161*	**0.205*** **	0.123**	**0.224*** **	0.154**	**0.222*** **	**0.239*** **
Possibility	Risk perception	0.189***	**0.250****	0.182***	0.159**	0.197***	**0.201*** **	0.189***	0.172***
Possibility	Universalism	**0.214*** **	**0.257*** **	**0.210*** **	0.172**	**0.223*** **	**0.347*** **	0.196***	**0.266*** **
Possibility	Climate belief	**0.318*** **	**0.313*** **	**0.319*** **	**0.414*** **	**0.298*** **	**0.223*** **	**0.324*** **	**0.260*** **
Responsibility	Opportunity	0.014	0.124	0.004	−0.006	0.021	−0.022	0.014	0.007
Responsibility	Risk perception	0.105***	0.146*	0.099***	0.063	0.117***	0.146*	0.096***	0.043*
Responsibility	Possibility	**0.360*** **	**0.234****	**0.378*** **	**0.433*** **	**0.340*** **	**0.282*** **	**0.374*** **	**0.534*** **
Responsibility	Climate belief	0.176***	**0.214****	0.171***	0.196**	0.117***	**0.279*** **	0.158***	**0.206*** **
Responsibility	Universalism	0.105***	0.170**	0.089***	0.061	0.117***	0.033	0.120***	0.164***
Responsibility	Achievement	−0.023	0.008	−0.023	0.047	−0.043*	0.056	−0.034°	−0.037*
Pro-environmental behavior	Responsibility	0.134***	0.138*	0.132***	**0.209****	0.118***	0.091	0.144***	-
Pro-environmental behavior	Opportunity	−0.045*	0.032	−0.053*	−0.019	−0.056*	−0.136*	−0.028	-
Pro-environmental behavior	Risk perception	−0.036	−0.099	−0.030	−0.052	−0.031	−0.112°	−0.024	-
Pro-environmental behavior	Possibility	**0.344*** **	**0.494*** **	**0.330*** **	**0.234*** **	**0.366*** **	**0.329*** **	**0.332*** **	-
Pro-environmental behavior	Climate belief	0.160***	0.127*	0.163***	0.196**	0.153***	**0.294*** **	0.148***	-
Pro-environmental behavior	Universalism	0.088***	0.059	0.085***	0.062	0.092***	0.058	0.088***	-
Pro-environmental behavior	Achievement	−0.002	−0.040	0.007	0.066	−0.017	−0.059	0.002	-
	SRMR	0.0108	0.0134	0.0096	0.0282	0.0082	0.012	0.013	0.032
	RMSEA	0.0279	0	0.0222	0.0828	0.0138	0	0.034	0
	CFI	0.9983	1	0.9989	0.9874	1	1	0.997	1
	χ^2_{df}	$2{,}774_{28}$	314_{28}	$2{,}406_{28}$	610_{28}	$2{,}212_{28}$	449_{28}	$2{,}275_{28}$	$2{,}869_{21}$

Negative connections are marked in red, and connections >|±0.200| are bolded. Non-significant connections are highlighted with gray. Statistical significance (H_0:|β|=0): °0.05 < p < 0.10, *p < 0.05, **p < 0.01, and ***p < 0.001. The three goodness-of-fit indices and chi-square value are shown below.

statistically significant (Table 2). For the model for women, many statistically significant relations from the values turned non-significant compared to the base model, from achievement to climate change belief (β = −0.087) and to opportunity (β = 0.041), and from universalism to risk perception (β = 0.040) and to pro-environmental behavior (β = 0.059). As a result, achievement became obsolete in the model altogether. The direct effects from universalism to climate change belief (β = 0.179**), to possibility (β = 0.257***), and to responsibility (β = 0.170*) were still in place. This would imply that achievement value has no effect to women's pro-environmental behavior and values alone do not predict pro-environmental behavior as much for women, as for the whole sample of farmers. The relation from climate change belief to opportunity strengthened (β = −0.212**) compared to the base model, as did the relations from opportunity to risk perception (β = −0.242***), from risk perception to possibility (0.250**), and from possibility to pro-environmental behavior (β = 0.494***). As a result, felt possibility to mitigate predicted pro-environmental behavior directly by 94%, and only 6% of its effect was mediated *via* felt responsibility (Appendix 4).

For *farmers under 40 years old,* **two** relations turned from negative to positive (from achievement to responsibility and to pro-environmental behavior) and one from positive to negative (from opportunity to responsibility). None of these relations were statistically significant. Statistical significance disappeared

from value-based relations as in the model for women (from achievement to climate change belief, and from universalism to responsibility and to pro-environmental behavior). The direct effect from possibility to pro-environmental behavior ($\beta = 0.234^{***}$) was lowest for younger farmers, but 10% its effect was mediated *via* responsibility (Appendix 4).

The model for *organic farmers* showed also differences to the basic model. The relations from achievement to climate change belief and from universalism to responsibility and to pro-environmental behavior lost their statistical significance. More strikingly, so did the relation from responsibility to pro-environmental behavior. However, the relations from universalism to climate change belief ($\beta = 0.457^{***}$) and to possibility ($\beta = 0.347^{***}$) strengthened compared to the base model. The direct effects of climate change belief to responsibility ($\beta = 0.279^{***}$) and to pro-environmental behavior ($\beta = 0.294^{***}$) were strongest for this farmer group, indicating the importance of universalism and climate change belief as more important predictors of pro-environmental action for organic farmers than for others.

Discussion

Psychological research can give new and important insights into the research aiming at transition toward low-carbon economies (Swim et al., 2011; Clayton et al., 2015). The VBN theory (Stern, 2000) has been widely used to study the elements of pro-environmental behavior and has also been the basis for agricultural research (Price and Leviston, 2014; Sanderson et al., 2018). Climate change opportunities have been presented in the media and discussed in Finland (Peltonen-Sainio et al., 2018, 2020) and other boreal countries (King et al., 2018; Unc et al., 2021), but the effect of these opportunities to pro-environmental action has not been studied. In this research, we introduced a new element of climate change opportunities to the VBN theory structure to study its effects. We also experimented with separate models for different farmer groups and two different points in time.

Although this study contributes to the literature of VBN applications in farmer mitigation behavior, there is a set of limitations that should be considered when interpreting the results. First, the time-variant survey questionnaires were not designed homogeneously as regards to one statement (pro-environmental behavior), which prevented a full comparison of the predictive models. Thus, the comparison cannot be made at the model level, and only the other connections can be compared. Second, terminology used in different disciplines doing similar research is not coherent. This results in difficulties when trying to do transdisciplinary research and apply the methods to new sectors, such as agriculture. We have tried to address this issue in this research.

Our first hypothesis on the causal path from values to pro-environmental behavior according to the VBN theory was confirmed. The base model for 2020 predicted 30% of pro-environmental behavior within the farmer community and 29–40% was reached with the models for different farmer groups. Although the results from previous research were confirmed in many parts, there were also interesting differences. Starting from the *values*, unlike Sanderson et al. (2018), universalism was found to have both direct and indirect positive effects to all VBN theory elements, including pro-environmental behavior among the farming community (Figure 2; Table 2; Appendix 3), similar to the results of Price and Leviston (2014). Still, the effect was stronger, when it was mediated via the other theory elements, but direct effects were found from the 2020 base model and models for men, conventional farmers, and older farmers (Table 2). For women, organic, and younger farmers, the direct effect of universalism did not reach pro-environmental behavior, indicating that within these groups, a certain value base alone does not motivate direct pro-environmental behavior. The strongest direct connection from universalism was to felt possibility to influence agricultural emission in agriculture. This would indicate that pro-environmental values activate farmers to consider whether and how climate change could be addressed and find ways to mitigate these risks. The value of achievement, a self-enhancement value in the Schwartz et al. (2012) basic human values theory, was found to have a negative relation to climate change belief as reported in previous research (Schultz et al., 2005). Besides climate change belief, achievement is connected directly and positively to opportunity, but not to any other variables. In the model for women, the connections from achievement were not statistically significant to any of the other variables studied. This would imply that values having more personal focus do not impact pro-environmental behavior.

Belief of anthropogenic origins of climate change had a strong direct effect to risk perception and to felt possibility to mitigate (Figure 2). This connection has been repeatedly found in previous research, including in the agricultural sector (e.g., Niles, Lubell and Haden, 2013), and holds in it the idea that people can fix problems that they have created themselves (Böhm and Tanner, 2019). *Risk perception* acted as a mediator between the following VBN theory elements, but its direct effects were considerably lower than expected. Surprisingly, there was no direct effect from risk perception to pro-environmental behavior. Our results on risk perception confirm that the risks associated with climate change do not relate to everyday experiences that would lead to pro-environmental behavior (Leiserowitz, 2006; Weber, 2006; Haden et al., 2012) in the Finnish agricultural context.

The cause for the low importance of risk perception can be explained also through its connection to opportunities. Our

second hypothesis on the negative effect of climate change *opportunities* to risk perception was confirmed indicating that the prospects of opportunities leave behind the possible risks that might occur in future. Here, biases and heuristics might also be relevant. Because of optimism bias, people tend to believe that positive events are more likely to happen to themselves and negative events to others (Weinstein, 1980). Affect heuristic, on the contrary, impacts through positive feeling (such as prospective opportunities) that result to risks being evaluated smaller than they actually are (Finucane et al., 2000). The role of biases and heuristics in pro-environmental behavior is interesting and would need more research.

Our hypothesis on negative effects of climate change opportunity had to be rejected in the case of felt *possibility* to mitigate climate change (Figure 2; Table 2). Here, the relation was strong and interestingly positive. What could be the connection between farmers believing in climate change opportunities and simultaneously believing in their possibilities to mitigate? This might originate from the same belief that humans are capable of solving man-made problems as was stated for the climate change beliefs' connection to possibilities. One idea could be that as the discussion in Finland has concentrated strongly on the possibilities of agriculture and farmers to mitigate climate change and the support offered to farmers for doing so (e.g., subsidies for carbon farming), this has strengthened both aspects, opportunities and possibilities. From this perspective, the opportunities of climate change come from the mitigation possibility that the farmers have and not from the direct effects of global warming. In the absence of previous research on climate change opportunities and its psychological effects to pro-environmental behavior, we look forward to the results of future studies to bring light into this interesting finding.

Felt possibility to mitigate climate change was the strongest predictor for pro-environmental behavior in all other groups studied, except young farmers (Table 2, Appendices 3, 4). Our results are similar with Price and Leviston (2014), who found that locus control (a form of self-efficacy) was the strongest predictor for pro-environmental behavior. This means that for farmers, it is most crucial to know that one can perform the pro-environmental behavior in practice.

This research has concentrated on farmers' mitigation behavior as a form of pro-environmental behavior. As the drivers for climate change adaptation in agriculture seem to differ from mitigation (Zhang et al., 2020; Sorvali et al., 2021), the connections between climate change opportunities and adaptation behavior should be studied further. As farmers are not a uniform group either based on their value profiles (Sorvali et al., 2022), their climate change views (Sorvali et al., 2021) nor the predictors of pro-environmental behavior studied here, more research should be focused on studying the differences between groups and the barriers and drivers for the different groups as regards to pro-environmental behavior. Young farmers would be one group of special interest as they will be the actors responsible for the future development of agriculture, and there seem to be fundamental differences in their thinking compared to the older farmer generation. The longitudinal aspect would also benefit from further research. The development of future environmental policy in the agricultural sector would benefit from the knowledge that which predictors of pro-environmental behavior change the most in time and what factors contribute to that change. Besides the research on the role of heuristics and biases effecting pro-environmental behavior mentioned earlier, there are still many other aspects to be considered. The role of emotions as an important predictor of pro-environmental behavior has been brought up in the literature concerning risk perception and decision-making under uncertainty (Brosch, 2021) and should also be studied in the context of agriculture and climate change mitigation. As farming is much more a lifestyle rooted in traditions and not just an occupation, emotions might help to predict also pro-environmental behavior better. Also, the literature on fair distribution of mitigation burden and farmers' views on climate justice has started to emerge (Puupponen et al., 2022) and that also might contribute to the VBN theoretical framework.

Conclusion

Farmers are the only actors capable of mitigating climate change impacts in agriculture at the farm level, and the impact of their action is therefore crucial. As the possibility to mitigate proved to be of such crucial importance in predicting pro-environmental behavior, our results seem to confirm Stern (2000) hypothesis, where the more important behavior is in terms of its environmental impact, the less behavior is dependent on attitudinal variables, such as climate change belief or risk perception. Therefore, future efforts in agricultural research and policy should concentrate on bringing forth concrete farm-level mitigation practices with proven environmental benefits. This would be the most effective way to promote the low-carbon transition of agriculture.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

Conceptualization, writing—original draft preparation, and writing—review and editing: JS, XL, and JK. Methodology: JS. Formal analysis and investigation: JK. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.939201/full#supplementary-material

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Consistent or inconsistent? The effects of inducing cognitive dissonance vs. cognitive consonance on the intention to engage in pro-environmental behaviors

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How do individuals rationalize the cognitive dissonance between their environmental awareness and the maintenance of environmentally unfriendly behaviors? The main goal is to explore the rationalization strategies used by individuals in order to maintain their current behaviors. The secondary goal is to understand if it is possible to induce cognitive consonance, and how this influences intention to change. We present a study (N = 222) with three experimental conditions: inconsistency, control, and consistency. The method to induce inconsistency and consistency was inspired by the paradigm of induced hypocrisy. Results demonstrated that induced inconsistency elicits two main barriers in participants: considering the change as unnecessary, and perceiving to lack knowledge about how to change. Induced consistency elicits tokenism, resulting in a licensing effect. However, behavioral intentions did not differ among experimental groups. Results are discussed considering methodological limitations and possible intervening variable.

KEYWORDS

cognitive dissonance, cognitive consonance, psychological barriers, intention to change, pro-environmental behavior

Introduction

Despite the high level of public awareness about the environmental impact of human activity, there is a significant gap between the attitudes and the behaviors of individuals toward the protection of the environment. A recent worldwide survey on the public understanding of climate change (Leiserowitz et al., 2021) shows that if the majority of the participants recognize that climate change is happening (91% in France, 90% in the United Kingdom, 80% in the United States), only a small percentage would be ready to participate in a citizen's campaign urging action to reduce climate change (21% in France, 17% in the United Kingdom, 20% in the United States). If the literature about

pro-environmental behavioral change usually focuses on the psychological dimensions motivating individuals to engage in such a change (e.g., Kothe et al., 2019; Yuriev et al., 2020), it is also important, when developing education and communication campaigns, to understand the psychological barriers to individuals' decision to engage in behavioral change. Numerous studies have analyzed the psychological barriers that prevent individuals from engaging in pro-environmental behaviors (e.g., Lacroix et al., 2019), such as the perception of behavioral change as unnecessary, including the belief in technological solutions, feelings of powerlessness, and denial of responsibility for climate change. People may also fail to act when they feel a lack of knowledge about how to take action to protect the environment, or because they find it difficult to change their habits, or that the costs and constraints of the new behavior are perceived as too high (i.e., conflicting goals and aspirations). To these barriers is added the weight of the norms of people's surroundings, or the importance of other people's views on changing one's behavior (i.e., interpersonal relations). Finally, some individuals consider their efforts sufficient, thus hindering them in adopting new pro-environmental behaviors; this is a phenomenon called "tokenism," where individuals consider they have done enough and will not do anything more. If such barriers have been identified as determining inaction with regards to different environmental issues (e.g., climate change mitigation; Lacroix et al., 2019; biodiversity conservation; Bosone et al., under revision), it is still not clear which ones are used by individuals to justify their maintenance of the gap between their awareness and their behaviors, which creates cognitive dissonance.

Cognitive dissonance is a situation of incongruence between attitudes and behaviors that lead to a negative affective state characterized by discomfort, tension and physiological arousal (Festinger, 1957). Such negative affective state makes it unpleasant to hold inconsistent attitudes and/or perceptions or to behave inconsistently (e.g., Zanna and Cooper, 1974; Elliot and Devine, 1994). The desire to resolve cognitive dissonance drives individuals either to change their behavior in order to behave consistently, or to change their beliefs so that they are consistent with the current behavior, or yet to justify (i.e., rationalize) such discrepancy to make it bearable (McGrath, 2017).

Individuals who are aware of environmental problems but do not act to prevent them are confronted with this state of discomfort. To justify such a gap, they can engage in rationalization strategies, allowing them to keep their current behaviors while knowing that they are not contributing to the protection of the environment. We argue that some of the aforementioned psychological barriers to environmental action could actually be rationalization strategies to justify the maintenance of a behavioral inconsistency (i.e., cognitive dissonance). Clearly identifying such rationalization strategies could have important applied implications, potentially guiding education and communication programs targeting individuals who are already sensitive to their environmental impact, but who have yet to improve their pro-environmental efforts.

This is the main objective of the present paper: to analyze which barriers are the most highlighted by individuals who are in a state of cognitive dissonance, which can be obtained experimentally by inducing inconsistency (also defined as "induced hypocrisy"; Priolo et al., 2019).

Induced inconsistency

Induced inconsistency appears to be a paradigm of cognitive dissonance (Aronson et al., 1991; Fointiat, 2004). This technique triggers cognitive dissonance reaction among participants or citizens, to study and induce a behavior change. Two steps are necessary for individuals to become aware of their state of inconsistency ("hypocrisy") between their beliefs and their actions.

In the first stage of the induced hypocrisy technique, participants of the studies are led to declare or to recognize a normative behavior or a general norm (e.g., presenting a scientific expert delivering a speech stating that researchers are now convinced that human behavior is the source of global warming; Priolo et al., 2016). Recalling the transgression is the second step in the method of induced hypocrisy. Researchers create a situation of dissonance between the previously stated norm and the participant's behavior, by asking individuals to recall and describe past occasions when they failed to adopt a pro-environmental behavior (Harmon-Jones et al., 2003).

Such induced state of cognitive dissonance can encourage a change of intention as well as observed behavior (such as frequency and amount of donation; Priolo et al., 2016; Odou et al., 2019). However, no study has yet used this technique to observe which psychological barriers become rationalization strategies for individuals in a condition of induced inconsistency. This is thus the main aim of our research. Such a methodology brings us to a second research question: if it is possible to induce inconsistency and thus increase behaviors by asking people to remember how often they failed to adopt pro-environmental behaviors, does that mean that it is also possible to induce consistency? And would this decrease behavior?

Induced consistency

This second research question poses a methodological dilemma, because if asking individuals to remember how many times they have failed in the past to adopt pro-environmental behavior is an effective technique to induce inconsistency, then asking individuals how many times they have adopted the behaviors in the past could induce consistency. Being this a

way used by many researchers to measure past behaviors, before exposing participants to interventions promoting behavioral change, in a pre/post-intervention analysis that is often advocated to assess actual behavioral change (e.g., Abrahamse and Matthies, 2018; Miller, 2021), it would be important to understand whether this could bias the answers of the participants.

Based on past literature, two opposite hypotheses could be argued with regards to a positive vs. negative impact of such induced consistency on behavioral intentions.

On one hand, asking individuals to recall how many times they behaved pro-environmentally could influence their perception of themselves as people who are respectful of the environment, thus affecting their pro-environmental self-identity (Sparks and Shepherd, 1992; Stryker and Burke, 2000; Cook et al., 2002; Christensen et al., 2004). An individual's self-identity determines the consistency between his or her attitudes and actions, and thus assures the continuity of specific behaviors across different experiences and contexts. Past research has demonstrated how pro-environmental self-identity is a strong determinant of pro-environmental behavior across different areas, such as food consumption (Grewal et al., 2000; Cook et al., 2002), recycling (Mannetti et al., 2004) and in general pro-environmental action (Terry et al., 1999; Fekadu and Kraft, 2001). It is thus possible to suppose that induced consistency could boost pro-environmental self-identity and thus increase individuals' willingness to engage in even more pro-environmental behaviors. This would also be in line with the principles of the commitment theory (Kiesler, 1971; Girandola, 2005) which explains that once individuals act, they tend to become committed to their action, which creates a consolidation of the underlying attitudes. This would lead us to expect that the more individuals realize they have behaved pro-environmentally, the more they become committed to this, the more they intend to pursue such pro-environmental conduct.

However, the opposite could also be argued: asking participants to recall how much they have already engaged in pro-environmental behaviors could increase tokenism, which is one of the barriers to action (Gifford and Chen, 2017). Indeed, it has been demonstrated that after behaving pro-environmentally, one may feel they "have done enough," and have acquired a moral license to make less pro-environmental efforts (Kennedy et al., 2009; Nolan and Schultz, 2015; Geng et al., 2016). It is thus possible to suppose that individuals in a condition of induced consistency could feel as if they have already changed their behaviors in favor of the environment enough, and that anything more would be too much to handle. An increase in tokenism could thus decrease their intention to engage in more pro-environmental efforts.

A secondary objective is thus to understand (1) if it is possible to induce cognitive consonance, or consistency, by reminding individuals of their pro-environmental actions, and (2) in which direction induced consistency could influence individuals' intention to engage in specific individual and collective environmental actions.

Method

Participants and procedure

To estimate the sample size needed for this study, we used the effect size found in a recent meta-analysis of the effect of induced hypocrisy (Priolo et al., 2019). The meta-analysis ($k = 19$, $N = 1{,}127$) shows variation between a low and moderate correlation coefficient for the effect of induced hypocrisy on behavioral intention [$r = 0.35$, 95%CI (0.22, 0.46)]. Because we are also comparing dissonance and consonance in this study, we chose to be more conservative and determine the sample size on a small effect size ($r = 0.22$, corresponding to $f = 0.226$); G*Power indicates a sample size of at least 192 participants to achieve 80% power for an ANOVA analysis with 3 groups and 1 predictor. A total of 225 participants were recruited online, posting the link to the survey on several social media groups, not directly related to environmental issues.

Three were excluded for failing one or two instructional attention checks, leaving a sample of 221 participants (48.4% men and 51.1% women), aged 18–62 years ($M = 29.4$, $SD = 9.12$). Participants voluntarily answered to the survey and gave their agreement for the use of their data; data collection and analyses followed the latest General Data Protection Regulation. Participants were randomly assigned to one of three conditions: induced inconsistency, induced consistency, and a control condition. After giving their agreement, participants were asked to read a text about the consequences of CO_2 emissions on global warming and biodiversity loss. This is the first step for inducing cognitive inconsistency vs. consistency. The text emphasized the responsibility of each individual in the emission of CO_2 and therefore the importance of adopting pro-environmental behaviors (e.g., reducing meat consumption, private car use). Then, participants in the inconsistency condition were asked to recall how often they had failed to adopt a list of six pro-environmental behaviors in the previous month [1 = I never fail, 5 = I always fail; $\alpha(N = 6) = 0.88$], while participants in consistency condition were asked to recall how often they adopted these behaviors [1 = Never, 5 = Always when possible; $\alpha(N = 6) = 0.89$]. Participants in the control condition only read the message without being asked about their past behaviors.

All participants were then asked a series of close-ended scale questions about their current emotional state, the barriers they felt that prevented them from improving specific pro-environmental changes to their lifestyle, and their intention to do so. Finally, participants were thanked and fully debriefed about the objective of the study.

Measures

Emotional state

A short version of the dissonance thermometer was first administered in order to check for the effectiveness of the inconsistency and consistency induction (inspired by Priolo et al., 2016): four items measured (on a scale from 1—Not at all to 5—Completely) the participants' level of negative emotions (i.e., uncomfortable, embarrassed, bothered, and anxious; $\alpha = 0.83$) and four items measured the participants' level of positive emotions (i.e., content, good, proud, relaxed; $\alpha = 0.86$).

Psychological barriers

Psychological barriers to action were measured by a scale of 23 items adapted from the DIPB scale (Lacroix et al., 2019), asking participants to think about individual lifestyle changes to reduce carbon footprint, in favor of the environment. Participants were then asked to rate their agreement with the items on a 7 points Likert scale going from 1—Not at all to 5-Completely. Six factors emerged from a Principal Component Analysis, accounting for 74.3% of the variance in the dataset. Two items contributed to more than one factor and were then excluded from further analysis. The rest of the items were computed in order to create the mean score for each factor: the perception of the changes as unnecessary [$\alpha(N = 3) = 0.76$], lacking knowledge [$\alpha(N = 3) = 0.92$], the perception of such changes as being in conflict with their own goals and aspirations [$\alpha(N = 4) = 0.88$], interpersonal relationships [$\alpha(N = 4) = 0.87$], tokenism [$\alpha(N = 4) = 0.92$] and the external attribution of the responsibility for such changes [$\alpha(N = 3) = 0.66$]. The loading values of each factor are presented in **Supplementary Table 1**.

Pro-environmental self-identity

This was measured through the scale of pro-environmental self-identity adapted from Whitmarsh and O'Neill (2010), including four items on a 7-point agreement scale, such as "I think of myself as someone who is very concerned with environmental issues" [$\alpha(N = 4) = 0.70$].

Behavioral intentions

Participants were asked to declare to what extent they intend, in the future, to adopt four different pro-environmental behaviors [from 1 Not at all to 7 Completely; $\alpha(N = 4) = 0.90$]: to increase use of eco-friendly modes of transportation, to increase the accuracy of recycling, to buy local products more often, and to buy products with less packaging more often.

Results

We carried out a MANOVA to test the influence of consistency/inconsistency on positive and negative emotions, the six psychological barriers, pro-environmental self-identity and behavioral intention; all values are reported in **Table 1**, including power analysis and confidence intervals. When a significant result was obtained, we also carried out Tukey *post-hoc* tests to identify which groups significantly differed.

TABLE 1 MANOVA values.

Measure	F	p	η_p^2	95% CI
Behavioral intentions	2.70	0.069	0.024	[5.07; 5.72]
Positive emotions	9.14***	0.000	0.077	[2.34; 2.77]
Negative emotions	10.34***	0.000	0.086	[2.46; 2.86]
Psychological barriers				
Unnecessary change	4.44*	0.013	0.039	[2.35; 2.88]
Conflicting goals	1.93	0.147	0.017	[2.89; 3.45]
Interpersonal relationships	1.39	0.251	0.013	[1.84; 2.27]
Lack of knowledge	9.08***	0.000	0.077	[3.67; 4.36]
Tokenism	5.60***	0.004	0.049	[2.01; 2.63]
Externalization of responsibility	1.99	0.139	0.018	[4.19; 4.75]
Pro-environmental self-identity	2.05	0.131	0.018	[5.15; 5.57]

*$p < 0.05$, ***$p < 0.005$.

The decision to present the results of the MANOVA was taken in spite of the fact that all dependent dimensions did not distribute normally (all Shapiro-Wilk's test yielded a $p < 0.05$, except for the barrier "external attribution," for which Shapiro-Wilk's $p = 0.08$). This decision is due to the fact that appropriate non-parametric tests were also carried out (both Generalized Linear Models, and Kruskal-Wallis tests), and all of the tests yielded the same significant and non-significant results. Since results did not vary across different types of tests, we decided for clarity's sake to report here only the results of the MANOVA.

Before each analysis, we checked for outliers on the dependent variables (by examining the studentized residuals with a Bonferroni test). The only outlier was found on one of the barriers (change not necessary); we thus carried out the analysis to check for any possible difference due to this outlier. Since the analyses did not differ, we present in the following section all the analyses including the one outlier. The raw data supporting the conclusions of this article will be made available by the corresponding author, without undue reservation.

Behavioral intentions

The induction of consistency and inconsistency did not significantly influence behavioral intentions. However, there is a tendency to significance [$F_{(2,219)} = 2.71$, $p = 0.07$, $\eta_p^2 = 0.02$]: individuals in the consistency condition reported lower intentions ($M = 4.91$, $SD = 1.76$) than individuals in the inconsistency condition ($M = 5.39$, $SD = 1.43$) and in the control condition ($M = 5.39$, $SD = 1.19$). Tukey *post-hoc* tests did not show any significant difference; this tendency to significance suggests that further studies, with different methodologies, are needed (as presented in the discussion).

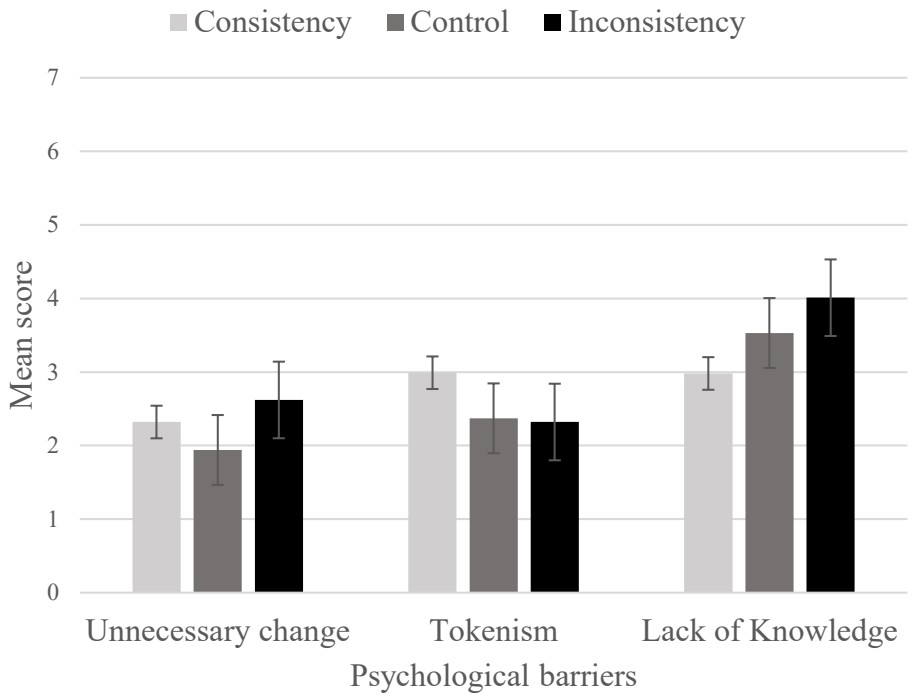

FIGURE 1
The effects of induced consistency/inconsistency on three psychological barriers. Error bars are standard errors.

Positive and negative emotions

The induction of consistency and inconsistency had a significant effect on positive [$F_{(2,219)} = 9.14$, $p < 0.001$, $\eta_p^2 = 0.08$] as well as negative emotions [$F_{(2,219)} = 10.34$, $p < 0.001$, $\eta_p^2 = 0.08$].

More precisely, individuals in the inconsistency condition reported lower positive emotions ($M = 2.55$, $SD = 1.02$) and higher negative emotions ($M = 2.66$, $SD = 0.98$) than individuals in the control condition (PE: $M = 3.11$, $SD = 0.84$; Tukey $p = 0.007$; NE: $M = 1.93$, $SD = 0.83$, Tukey $p < 0.001$) and in the consistency condition (PE: $M = 3.15$; $SD = 1.03$; Tukey $p < 0.001$; NE: $M = 2.22$, $SD = 0.92$, Tukey $p = 0.005$). The reported negative and positive emotions felt by individuals in the consistency condition and in the control condition did not significantly differ.

Psychological barriers

The induction of consistency and inconsistency had a significant effect on individuals' ratings of three of the six barriers to action identified: perception of the change as unnecessary, lacking of knowledge, and tokenism. Only these three barriers are discussed further in this section, and presented in Figure 1; however, the means and standard deviations for each barrier are reported in Table 2.

Perception of the change as unnecessary

Results shown that the ratings of the change as unnecessary were higher for individuals in the Inconsistency condition ($M = 2.62$; $SD = 1.29$) than the ratings of the individuals in

TABLE 2 Means, standard deviations of dependent variables for all conditions (only measures with significant MANOVA test are reported).

Measure	Consistency	Control	Inconsistency
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
Behavioral intention	4.91 (1.76)	5.39 (1.19)	5.39 (1.43)
Positive emotions	3.15_a (1.03)	3.11_a (0.84)	2.55_b (1.02)
Negative emotions	2.22_a (0.92)	1.93_a (0.83)	2.66_b (0.98)
Psychological barriers			
Unnecessary change	2.32 (1.26)	1.94a (1.07)	2.62b (1.29)
Conflicting goals	2.79 (1.34)	2.92 (1.21)	3.17 (1.31)
Interpersonal relations	1.83 (0.96)	2.07 (1.07)	2.06 (1.04)
Lack of knowledge	2.98_a (1.53)	3.53 (1.51)	4.01_b (1.75)
Tokenism	2.99_a (1.68)	2.37_b (0.96)	2.32_b (1.37)
External attribution	4.11 (1.43)	4.43 (1.05)	4.47 (1.25)
Pro-environmental self-identity	5.66 (0.99)	5.48 (1.05)	5.36 (0.94)

The means of the same dependent variable having different subscripts in the different experimental groups (subscript a vs. subscript b) differ significantly at $p < 0.05$ as indicated by Tukey *post hoc* tests. For instance, the means for positive emotions in the consistency and control group, with the subscript a, differ significantly from the mean for positive emotions in the inconsistency condition, with the subscript b.

the control condition (M = 1.94, SD = 1.07, Tukey p = 0.01). No significant difference was found between individuals in the inconsistency and in the consistency conditions (M = 2.32, SD = 1.26).

Lacking knowledge

The ratings of lacking knowledge as a barrier to action were higher for individuals in the Inconsistency condition (M = 4.01; SD = 1.76) than the ratings of the individuals in the consistency condition (M = 2.98; SD = 1.53; Tukey $p < 0.001$), but no significant difference was found between individuals in these conditions and the individuals in the control condition (M = 3.53, SD = 1.51).

Tokenism

Tokenism as a barrier to action was rated higher for individuals in the consistency condition (M = 2.99; SD = 1.68) than the ratings of the individuals in the control condition (M = 2.37; SD = 0.96; Tukey p = 0.05) and individuals in the inconsistency condition (M = 2.32, SD = 1.37, Tukey p = 0.006). The ratings of individuals in the inconsistency condition did not differ from the ratings of individuals in the control condition.

Pro-environmental self-identity

No significant difference was found when comparing the ratings of pro-environmental self-identity by individuals in the inconsistency vs. control vs. consistency conditions.

Discussion

The first objective of the present work was to identify which among the psychological barriers are also rationalization strategies that individuals use to justify, and thus accept, the dissonance between their environmental awareness and their inaction. To do so, we induced in a third of our sample a condition of cognitive dissonance using the paradigm of induced hypocrisy, by focusing their attention on the importance of the adoption of pro-environmental behaviors at the individual level and then asking them to recall how often they failed to adopt pro-environmental behaviors. Such induction was effective as demonstrated by the influence of our manipulation on positive and negative emotions felt by individuals in the inconsistency condition and individuals in the control condition.

As with regards to the psychological barriers, the comparison between the answers of individuals in the Inconsistency condition and individuals in the Control condition reveals that the consideration of the change as unnecessary is the barrier that is significantly more invested by the individuals when they are in a situation of cognitive dissonance.

The second objective of the present work was to verify whether it is also possible to induce a state of "cognitive consonance," corresponding to a state of consistency between the beliefs and the behaviors of the individuals, and whether this would modify their intention to engage in further pro-environmental efforts. To this purpose, the comparison between the answers of the individuals in the Consistency condition and the individuals in the Control condition with regards to their positive and negative emotions does not suggest that inducing Consistency has an effect on the emotional states of the individuals. However, the same comparison shows how inducing Consistency increases individuals' perception of having engaged in enough pro-environmental effort so that they don't need to do more ("tokenism"). This is in line with past work on the "licensing effect" (e.g., Burger et al., 2022), which defines a phenomenon where after behaving pro-environmentally, individuals may feel they have acquired a moral license to make less pro-environmental efforts (e.g., Geng et al., 2016). Considering past literature on spillover effects (Elf et al., 2019) as well as the consolidation effect of commitment (Kiesler, 1971; Girandola, 2005), further research should investigate more deeply what are the possible factors determining whether being aware of one's own pro-environmental behaviors result in licensing or spillover effects, such as individuals' concern with the environment. Indeed, individuals' pre-existing beliefs about climate and the environment, and their awareness of the problematic influence of human activity on them (e.g., Eisenack et al., 2014), could have modulated the effect of our induction, resulting in a stronger or weaker consistency and inconsistency. For instance, individuals' environmental self-identity could be a valuable moderator of the influence of consistency/inconsistency, especially considering that our data demonstrated that self-identity was not influenced by the induction. It would be possible to suppose for instance that the induction of inconsistency/consistency has an effect only for individuals with low environmental self-identity, as high environmental self-identity is strongly connected with pro-environmental behavior (Wang et al., 2021).

Present data showed that inconsistency activates a specific rationalization strategy that is considering the change as unnecessary, whereas consistency activates tokenism. This difference might suggest that while considering the change as unnecessary is indeed a rationalization strategy to justify the maintenance of a *status quo* which is inconsistent with personal beliefs, tokenism is rather a thought emerging from reflecting on one's own behaviors which could bias research on this topic. Further, lacking knowledge also differs between induced consistency and inconsistency, however, the fact that neither differ significantly from the control condition prevent us from concluding whether it is a barrier activated by inconsistency,

or whether this corresponds to a real lack of knowledge. Further research could include a measure of knowledge (e.g., Prévot et al., 2018), and problem awareness as we suggested above, before the induction of consistency/inconsistency.

These effects of induced inconsistency and consistency do not seem to consequently influence individuals' behavioral intentions, as the comparison between the control condition and the conditions where inconsistency or consistency were induced does not yield significant differences. Indeed, only a tendency to significance emerges when comparing individuals' intentions in the three conditions. The non-significant difference between the Inconsistency and the Control condition seems in contrast with past literature about induced hypocrisy, which demonstrated that triggering a state of cognitive dissonance increased behavioral intentions (for a review, see Priolo et al., 2019). This could be linked to three possible reasons: the first reason has to do with the method used to induce cognitive dissonance. Indeed, in the present study, we did not ask participants to express their belief about the importance of individuals' pro-environmental actions, but rather we explicitly focused their attention on it by asking them to read a text about this. This might have limited the cognitive dissonance felt by individuals, as our method of induction did not trigger a contrast between their beliefs and their actions, but rather between what they should do and what they failed to do. A pre-test would be needed to further confirm that the texts really increased the salience of their normative believes. Moreover, we induced consistency and inconsistency by asking individuals about six specific behaviors, while past research has demonstrated that reporting too many transgressions can reduce the hypocrisy effect (Fointiat et al., 2008; Stone and Fernandez, 2011). Further research could try to replicate present findings with a more traditional method to induce hypocrisy.

A second reason could depend on the fact that the behaviors targeted (mobility choices, recycling, purchasing) usually have the features of behavioral habits. Indeed, although many behaviors originate from thinking and considering possible alternatives, individuals do not go through such deliberate decisional process for actions that are repeated regularly and frequently (Aarts et al., 1998). When the same behavior is adopted many times and very often, such as buying specific products or using a specific transportation mode (e.g., driving a car), it can become a habit. Habitual behaviors are extremely resistant to permanent change (e.g., eating habits), and others are only changed slowly, over decades, making them resistant even to priming and attitude change (Verplanken and Aarts, 1999). It would thus be expected that individuals with strong recycling, purchasing and driving habits might not be as sensible to cognitive dissonance as other individuals with weaker habits. Future research could focus on measuring how the motivating effect of triggering cognitive dissonance to promote pro-environmental attitudes and behavior could vary depending on the strength of specific behavioral habits.

A third possibility might be the fact that behavioral intention are measured after psychological barriers, and it is possible that thinking about the reasons why individuals do not behave pro-environmentally might offer them a justification for it, and thus decrease the influence of induced inconsistency. Further research should thus explore whether the effects of induced inconsistency and consistency on behavioral intentions are stronger if psychological barriers are measured after the intentions.

It is important to point out that this study offers preliminary findings on the risk of inducing consistency by asking individuals how often they engaged in pro-environmental behaviors in the period before participating to the study, which is a technique used frequently to establish a baseline of pro-environmental behaviors. Indeed, data shows that individuals in the Consistency condition reported higher rates of tokenism than individuals in the inconsistency or control conditions. However, in the current study we only used subjective measures of consistency/inconsistency and intention. Further research could investigate further this effect combining objective measures, such as physiological measures of negative emotions induced by cognitive dissonance (e.g., Colosio et al., 2017), as well as implicit measures, such as implicit association tests (e.g., Panzone et al., 2016).

Overall, present findings offer important theoretical contributions and potential practical implications. On one hand, identifying the rationalization strategies used by individuals to maintain environmentally harmful behaviors in spite of evidence on the necessity to change is a very important knowledge in order to guide the development of education and communication programs. Indeed, an effective intervention motivates citizens by pushing on the right levers, but also by tackling the possible cognitive barriers to change.

Present findings concern individuals in an induced state of cognitive dissonance, and thus need further empirical confirmation—concerning individuals in a "natural" state of cognitive dissonance—to corroborate their applied impact. However, it is possible to propose some insights on how these data could inform education and communication programs. For instance, our data demonstrated that individuals in a condition of cognitive dissonance consider the change proposed as unnecessary more strongly than individuals in the other conditions. This finding points to the fact that the perception of the change as unnecessary might indeed be the main barrier to be tackled by education and communication programs. In order to prevent such a rationalization strategy, messages used in such programs should focus more on the positive consequences of changing one's own behaviors, aiming at improving individuals' perception of the effectiveness and utility of the changes promoted. Communication strategies could also be used to nudge individuals toward considering the change as effective and necessary. For instance, it could be possible to match the message framing to the behaviors

promoted. Indeed, it has been demonstrated (Bosone et al., 2015) that gain-framing improves perceived effectiveness of additive behaviors (i.e., doing something new, such as enroll in a mobility challenge), whereas loss-framing improves perceived effectiveness of subtractive behaviors (i.e., reducing a harmful behavior, such as reducing the use of one's own car to commute). Another example could be to nudge individuals by using a narrative format, rather than a numerical one, to present data about the behavioral change proposed, as current research has demonstrated that narratives are more effective than statistics in increasing perceived response-efficacy (Bosone et al., under revision). These communication nudging techniques could improve individuals' consideration of the utility of changing their behaviors, thus preventing rationalization strategies to set in motion.

On the other hand, present findings warn about the risk of inducing cognitive consonance by asking individuals to recall their engagement in pro-environmental behaviors before a behavioral change intervention, as this could bias its effectiveness. This is the first time that such a concept of cognitive consonance has been tested experimentally and will need further analysis to propose possible solutions to measure behavioral baselines before behavioral change interventions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors upon request, without undue reservation.

Author contributions

LB conceived the study, participated in its design and coordination, as well as to data collection and analysis, and wrote the first draft of the article. MC participated in the design of the study, the data collection and analyses, as well as in the writing, and formatting of the article. FZ participated in the data analyses, as well as in the revision and formatting of the manuscript. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Linking environmental psychology and critical social psychology: Theoretical considerations toward a comprehensive research agenda

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In order to foster pro-environmental behavior in the midst of a global ecological crisis, current research in environmental psychology is often limited to individual-related factors and theories about conscious processing. However, in recent years, we observe a certain discontentment with the limitations of this approach within the community as well as increasing efforts toward broadening the scope (e.g., promotions of collective and social identity processes). In our work, we aim for a closer investigation of the relations between individuals, societal factors, and pro-environmental actions while considering the role of the unconscious. We hereby draw on the work of critical social psychology (CSP). From a life course perspective, we emphasize the important role of socialization, institutional and cultural contexts for mindsets and related perceptions, decisions and actions. This link between the individual and the society enables us to understand biographical trajectories and related ideologies dominant within a society. We seek to show that the approach of CSP is helpful for understanding why efforts of establishing pro-environmental actions on a large scale are still failing. In this article, we discuss the theoretical links between environmental psychology and CSP as well as possible implications, paving the way for a comprehensive future research agenda.

KEYWORDS

critical social psychology, critical environmental psychology, pro-environmental behavior, qualitative research, life course research

Introduction

Being acknowledged as a sub-discipline of psychology from the 1960s onward, environmental psychology has been concerned with the interplay of humans and their environment. An early focus that is still an important part of environmental psychology today is the question of how various (built, natural, social, today also digital)

environments influence perceptions, cognitions, feelings, and behavior of humans. Furthermore, environmental psychology has a tradition of engaging with questions of environmental sustainability[1] since the emergence of larger-scale awareness of ecological crises in science and society in the 1970s and 1980s (for more details on main characteristics and the historical development of the field, see, e.g., Gifford, 2007, pp. 199–207; Pol, 2006, 2007; Steg et al., 2013, pp. 2–6). Since the beginning of the 21st century, environmental psychologists have been particularly concerned with the link between human behavior and the anthropogenic destabilization and destruction of global ecosystems, most prominently in the case of anthropogenic climate change. Recognizing climate change as a major threat to the foundations of human existence (Intergovernmental Panel on Climate Change, 2022a, pp. 10–21), environmental psychologists investigate the underlying reasons for environmentally significant human behavior, the potential for behavior change, as well as concrete measures and interventions to foster behavior change. The unifying objective of theoretical and practical efforts in the field is that of ecological, social, and economic sustainability (Steg et al., 2013, p. 4).

Undoubtedly, environmental psychology has advanced our understanding of factors that influence environmentally significant human behavior. A rich body of studies shows a multitude of factors both within individuals (such as attitudes, control beliefs, values and moral norms, affects, personality factors) and outside individuals (such as social norms, costs in terms of time, effort, and money, aspects of infrastructural design, policy measures) that influence environmentally significant behavior (e.g., Bamberg and Möser, 2007; Klöckner, 2013; Gifford and Nilsson, 2014; van der Linden and Goldberg, 2020). While, in general, diversity of theories and research methods is one of the characteristics of the field (Steg et al., 2013, p. 6; for an overview of common methods, see Gifford, 2016), research in this tradition is often based on action models, quantitative survey studies, and correlational analyses of possible underlying factors of the behaviors of interest. Based on such theories and respective empirical findings, environmental psychologists traditionally suggest leverage points to promote behavior change to policy makers (e.g., Gardner and Stern, 2009; Wolske and Stern, 2018; Nielsen et al., 2020). Moreover, environmental psychologists have a long tradition of directly implementing and scientifically evaluating concrete measures to promote behavior change in practice, linking with insights from action research (e.g., McKenzie-Mohr, 2000; Abrahamse et al., 2005; Steg and Vlek, 2009; Osbaldiston and Schott, 2012; Schultz, 2014).

Despite these achievements, our observation from being engaged in the environmental psychology community is also that of a certain level of discontentment, reflecting current challenges of the field. One major challenge for researchers working on topics related to climate change is their high level of knowledge about the tremendous dangers of climate change and about various possible actions toward mitigation while simultaneously observing that humanity is still failing to address the climate crisis appropriately (*implementation gap*; Intergovernmental Panel on Climate Change, 2022b, p. 15). Continually experiencing this contrast can be a driver, but also a heavy mental burden that can be experienced as overwhelming and can lead to severe negative effects on mental health (e.g., Head and Harada, 2017; Clayton, 2018). More specifically related to the field of environmental psychology, there seems to be a growing dissatisfaction of the lack of impact that research has so far made in practice, leading to concerns that "psychology is falling short of its potential" (Nielsen et al., 2020, pp. 3–4). Searching for explanations, environmental psychologists recently have been questioning the primary focus on individual (consumption) behavior change in the discipline (e.g., Amel et al., 2017, p. 3; Wallis et al., 2021, pp. 184–186; Wullenkord and Hamann, 2021, pp. 1–2) and the spheres of behavior typically addressed[2] (e.g., Moser and Kleinhückelkotten, 2018, pp. 627–631; Nielsen et al., 2020, pp. 3–6). Some alternative suggestions researchers have recently made are that environmental psychologists should focus more on predictors of high-impact behaviors (e.g., Wolske and Stern, 2018; Nielsen et al., 2020, 2021), on predictors of collective action, social and societal change, and change of cultural norms (e.g., Amel et al., 2017; Fritsche et al., 2017; Wallis et al., 2021), on more inter- and trans-disciplinary collaborations (Clayton et al., 2016a), or on the links between individual behavior change and

1 While acknowledging diverse conceptualizations of the terms *sustainability* and *sustainable development*, in this article, we refer to the comprehensive concept defined by the World Commission on Environment and Development (1987). This concept encompasses economic, ecological, and social aspects and aims at ensuring to meet the needs of all humans (hereby emphasizing the needs of poor and marginalized people) in the present without harming the needs of all humans in future generations.

2 This debate is usually labeled as a conflict between *intent*- vs. *impact*-oriented research (cf. Moser and Kleinhückelkotten, 2018): Intent-oriented research in environmental psychology focuses on peoples' pro-environmental motivation and moral norms, mainly in the sphere of habitualized household behaviors. Studies show that such factors can indeed predict the readiness to act pro-environmentally, however, the environmental impact of performing such behaviors was found to be relatively low. Impact-oriented research promotes to focus on spheres of behavior with a relatively high environmental impact first, such as energy-related investment decisions. Studies have found that socioeconomic variables are much more important predictors here than in the sphere of habitualized household behaviors. As environmental psychologists have traditionally been leaning more toward studying pro-environmental behavior from an intent-oriented perspective, impact-oriented researchers suggest more studies on predictors of high-impact behaviors and to investigate closer how the difference in the most influential predictors can be explained. The long-ongoing debate within the environmental psychology community has recently gained new momentum (e.g., Nielsen et al., 2021; van Valkengoed et al., 2021).

changes in the socio-economic system (e.g., Wallis et al., 2021; Wullenkord and Hamann, 2021).

Some researchers from the discipline go a step further when investigating challenges of the discipline, being more fundamental in their critique. As the current ecological crisis is rooted in the economic systems, lifestyles, and ideologies in the industrialized nations and these strongly influence the academic careers and practices of academic research, they suggest that environmental psychology would benefit from a stronger reflection of ideological influences as well as influences of structures and power when trying to play an active role in socio-ecological change (Uzzell and Räthzel, 2009; Krenzer and Kreil, 2019; Räthzel and Uzzell, 2019; Schmitt et al., 2020; Krenzer, 2020; Adams, 2021). Consequently, environmental psychology's key assumptions, paradigms, and methods would have to be questioned and readjusted to conduct more meaningful and practically relevant research. One major criticism in this respect is that theories and research practice in the field have not only been focusing too much on individual behavior change, but have been treating individuals as privatized, static, egocentric, and more or less independent actors (e.g., Räthzel and Uzzell, 2019, pp. 1377–1380; Schmitt et al., 2020, pp. 124–130; Adams, 2021, pp. 14–15). This concept of human beings would downplay the importance of social relations and the larger social context, societal structures and power relations, as well as the dynamics in individual biographies and societal processes (Ibid.). For example, in this view, it would be of much importance what kinds of pro-environmental attitudes, values, or social norms are (re)produced in the concrete context of individuals and how these are "shaped through relations of power, the economic structure of society, and the dominant ideologies and forms of politics" (Räthzel and Uzzell, 2019, p. 1390). Investigations of the social embeddedness of intra-individual processes would have to be sensitive for the complexity, ambivalences, contradictions, and processual nature of everyday life as well as the complex role of emotions and affects. This challenges the discipline's predominant methodological approach of quantitative analyses with a focus on the *status quo* in the present (or a relative short timeframe, respectively; examples would be correlational studies or laboratory and field experiments; see above, cf. Lertzman, 2019, pp. 26–28). However, by critically challenging the *status quo*, environmental psychologists would have to take political stances more explicitly and be more directly involved in ongoing processes of change, which might conflict with the ideal of political neutrality prevalent in the discipline and in science in general (Krenzer and Kreil, 2019, pp. 167–168).

To sum up, despite undeniable achievements of the past, we are currently observing a discipline with researchers dissatisfied on different levels. The central challenge seems to be how the discipline can adapt to increase its impact and take on a more central role in promoting large-scale societal and systemic change within the social-ecological transformation. In this respect, we observe a general openness toward new directions and more multiperspectivity in the community.

For such an undertaking, we argue that it is both fruitful and necessary to engage with the aforementioned issues that critical researchers have pointed out, paving the way toward a *critical environmental psychology*.[3] In the following, we will outline how, in this respect, the perspective of *critical social psychology* could be combined with questions of and challenges within environmental psychology. Especially from the view of a life course perspective (Kühn, 2015), our objective is to introduce pillars of a suitable framework and demonstrate possibilities for its application in order to spark further discussions.

In section "Alternative trends in current environmental psychology research fostering a critical perspective," we point out developments in environmental psychology that, from our perspective, link well with the aforementioned approach. In section "Fundamental considerations on the importance of critical social psychology for environmental psychology," we substantiate and elaborate this perspective by offering fundamental considerations on the benefits of critical social psychology for environmental psychology. In section "Critical environmental psychology from a life course perspective," we demonstrate the potential for future research by providing examples of a qualitative approach within life course research. Finally, in section "Conclusion," we conclude and provide an outlook for further research.

Alternative trends in current environmental psychology research fostering a critical perspective

Since its origins, research in the field of environmental psychology has always been diverse, integrating ideas from and orienting toward other scientific disciplines and being constantly influenced by new scientific knowledge from other

3 Researchers from the field of environmental psychology have recently linked the term *critical environmental psychology* particularly to critical psychology in the tradition of Holzkamp (1983; cf. Krenzer and Kreil, 2019, pp. 163-164; Räthzel and Uzzell, 2019, pp. 1376-1377). We completely agree with the benefits that would come from integrating insights from this research tradition systematically into research practices and theories in environmental psychology. However, in this article, we use the term as an umbrella term, referring to a general approach rather than a specific theoretical framework. Such an approach would be characterized by critically (self-)reflecting upon the underlying paradigms, theories, conceptualizations, and methods of research in the field by emphasizing the importance of social relations, social inequalities and (power) structures as well as by taking historical-cultural contexts, biographical socialization processes, and the dynamics of developments within and between individuals and society into account (see section "Fundamental considerations on the importance of critical social psychology for environmental psychology"; cf. Tuffin, 2005; Parker, 2007; Billig, 2008; Kühn, 2015).

fields as well as emerging trends and practices in the society and macro-developments (Steg et al., 2013, pp. 5–6). Here, we will briefly describe some theories and trends we have observed in recent years that, from our point of view, are challenging or enhancing the predominant course of research in the field. The collection is not intended to be exhaustive. The approaches that we mention are investigating the interplay between humans and their environment while integrating aspects of the societal context, social inequalities, social change, or social discourse, dealing with questions of inequality or embedding non-intentional or non-rational processes.

Such approaches are usually implemented by specific working groups, within (time-limited) projects or by researchers of a similar tradition or orientation, sometimes within research clusters. While they are certainly known by many researchers in the field of environmental psychology, the ideas and results have, at least so far, not been integrated systematically in the quantitative individual-focused research based on action models that has dominated the field in its recent history. Furthermore, the researchers investigating these perspectives rarely systematically linked the mentioned approaches to one another. By this, we are in no way calling for the development of a coherent, comprehensive framework for the discipline, which might prove impossible due to the variety and complexity of the topics of interest (Stern, 2000). However, as stated before, we are emphasizing that research in the discipline should systematically implement perspectives from a fundamentally critical stance. In this respect, from our point of view, these trends and theories accompany, enhance, and or pave the way toward a critical environmental psychology.

One of such trends is the increased interest in understanding and promoting social movements. The interactions of humans with their social environment has been of interest to the discipline from the beginning (Pol, 2006, p. 97). Furthermore, the relevance of public-sphere behavior and activism have always been somewhat on the radar of environmental psychologists concerned with ecological crises (e.g., Stern, 2000). In the last decade or so, environmental movements and collective forms of protest against ineffective large-scale political actions to mitigate climate change (such as the *Fridays for Future* movement) have grown, gained more and more media attention, and increased the pressure on politicians. Better understanding people's motivation to engage with, stay active in, and promote social movements currently has gained a lot of momentum in the environmental psychologists' community (e.g., Wallis et al., 2021). For example, researchers have been applying *social identity theory* (Tajfel and Turner, 1979) and the *social identity model of collective action* (van Zomeren et al., 2008) to explain engagement in environmental movements (Fritsche et al., 2017). Challenging the dominance of research on private-sphere individual behavior, looking at collective phenomena and collective behavior seems a promising path regarding that the magnitude of challenges and solutions has to be addressed at the societal level (Amel et al., 2017). In terms of critical agenda setting, increasingly focusing on perceived (social) injustice, social conflicts, and related emotions are noteworthy contributions. Furthermore, a stronger emphasis on social movements and social change can contribute to challenging predominant structures of social and environmental injustice.

Another noteworthy trend is that some environmental psychologists are currently striving for strengthening the links between their discipline and perspectives from (sociotechnical) system transformation research. One framework from system transformation research that is helpful to understanding the interplay between small-scale/individual activities and macro factors in social change is the *multi level perspective* (Geels, 2004; Geels and Schot, 2007). The theory describes how the *status quo* is manifested as a result of the complex interplay, interdependencies and path dependencies within and between industry, policy making, industry, technology, culture, and science. Furthermore, it offers perspectives on how large-scale societal change can take place (e.g., how pro-environmental alternatives to current practices and lifestyles can become mainstream). Environmental psychologists are currently striving to integrate theories from their field with this perspective to better understand how individual behavior change is embedded in large-scale societal transformation processes (e.g., Wallis et al., 2021; Wullenkord and Hamann, 2021). The benefit of this undertaking from a critical standpoint is that important parameters of the socio-economic and societal system are no longer neglected, but systematically linked with and incorporated into research on individual cognitions and behavior. Furthermore, the implication of this link is to investigate determinants of societal and systemic change, which is needed to appropriately tackle climate change and other ecological and social problems (see section "Introduction").

Another fruitful line of research in the discipline is linking psychological perspectives to interdisciplinary discourses on environmental justice (see, e.g., Mohai et al., 2009; Walker, 2012; Baasch, 2020) and energy justice (see, e.g., Sovacool and Dworkin, 2015; Jenkins et al., 2016, 2021). Environmental psychologists have investigated, for example, (a) subjective conceptualizations of justice related to environmental or energy-related problems or conflicts, (b) experiences and behaviors of relatively more and relatively less affected people and communities in this respect, both on the local (e.g., air, chemical, or noise pollution) and the global level (impacts of the destruction of large-scale eco-systems and, particularly, climate change), (c) the role of perceived (in)justice for pro-environmental behavior, and (d) psychological contributions to environmental conflict resolution (e.g., participation processes, mediation; for overviews of activities in the field, see, e.g., Clayton et al., 2016b; Kals and Baier, 2017; Baasch, 2020). While incorporating and highlighting societal issues of injustice from the very beginning, research from this perspective has recently become even more plural (Kals and Baier, 2017, pp. 82-88)

by also investigating questions of social (in)justice as well as more intersectional and critical perspectives and emphasizing the role of emotions and concepts such as discourse and agency to explain and foster resistance, participation, and change (e.g., Manning and Amel, 2014; Baasch, 2020; Cunsolo et al., 2020; Fernandes-Jesus et al., 2020; Groves et al., 2021; Makovi and Kasak-Gliboff, 2021; Nguyen and Batel, 2021). From a critical perspective, such studies are clearly important as they recognize the importance of predominant structures, power issues, and social injustices. Moreover, they investigate how such issues and discourses are perceived, reconstructed, and linked to environment-related cognitions and behavior. Research of this tradition is shedding light on boundaries set by systemic factors, thereby highlighting the limitations of individual behavior change and the need for structural and political action, but also helps to identify and bring forth new forms of agency.

When considering environmental justice, it is crucial to not only look at research and approaches from the Global North, but to systematically include approaches from the Global South (e.g., Kühn and Souza, 2006; Rehbein, 2011). Jodhka et al. (2017) show how dangerous a one-sided view of social environments can be. For example, it is especially problematic when development processes of societies are linked to explicit or implicit basic assumptions of modernization that are based exclusively on concepts of the Global North. From such a perspective, history appears as "an evolution toward a superior model of society embodied by European and North American nation-states" (Jodhka et al., 2017, p. 2). Jodhka et al. argue that "these assumptions contribute to the resilience of inequality and need to be overcome" (Ibid.). Important critical research and agenda setting has been done by researchers from environmental psychology from the Global South (e.g., with regard to environmental planning and urban design, people-place-relations, and community participation, among others; Wiesenfeld and Sánchez, 2002; Wiesenfeld, 2005; Farias and Diniz, 2018; Diniz et al., 2020). Furthermore, some fruitful work including critical perspectives has emerged from dialogue between researchers from the Global North and Global South (e.g., Devine-Wright et al., 2020; Raymond et al., 2021).

Another promising line of research not systematically integrated in mainstream research in environmental psychology is the tradition of *climate psychology* (e.g., Weintrobe, 2012; Hoggett, 2019). This line of research tries to better understand the, on a large scale, inappropriate reaction of humans toward the imminent threat of climate change by drawing strongly on psychodynamic theories (Searles, 1972), emphasizing the importance of emotions, emotional work, and defense mechanisms as well as dealing with psychological phenomena such as denial, anxiety, grief, or trauma (e.g., Weintrobe, 2012; Orange, 2016; Hoggett, 2019; Dodds, 2021). Insights from this tradition have recently been linked with more traditional research approaches from environmental psychology on climate change denial and climate anxiety (e.g., Clayton and Karazsia, 2020; Wullenkord et al., 2021; Wullenkord and Reese, 2021). From a critical perspective, involving psychodynamic approaches and, thereby, emphasizing emotions and defense mechanisms, certainly adds another important dimension to a field mostly focusing on consciousness in its research (methods), i.e., cognitions, thoughts, and rationality. This improves our understanding of important roots of everyday meaning and individual perceptions of environment-related matters.

Finally, we would like to mention the work that has been done with reference to social representation theory (Moscovici, 1961; Marková, 2008). Social representation theory hypothesizes that when knowledge is produced and shared, it is always shaped by processes of gaining social and cultural meaning. I.e., knowledge would be the product of social interaction and, at the same time, individual representation (Marková, 2008). Climate change would, in most cases (in industrialized nations), not directly and consciously be experienced through the human senses, but would rather be a socially constructed concept (e.g., Moloney et al., 2014). Research in environmental psychology could benefit from integrating social representations theory to address common problems of varying understandings and definitions of key concepts among the scientific community, in the general population, and in the dialogue between both. This could also potentially strengthen the link between measurement constructs representing environmentally significant attitudes and norms, on the one side, and environmentally significant behavior, on the other side, by highlighting misconceptions, ambivalences, and uncertainties currently neglected in many studies in the field (Castro, 2006; Castro et al., 2009; Batel and Devine-Wright, 2015; Batel and Castro, 2018). The critical implication of this line of research is that it recognizes the importance of individual everyday representations of relevant concepts as well as the importance of social discourse and everyday social interaction for environment-related cognitions and behavior. This perspective has important implications in terms of critical theory building but also methodology (see section “Fundamental considerations on the importance of critical social psychology for environmental psychology”).

To sum up, researchers with ties to environmental psychology have done much fruitful work in terms of critical agenda setting and conducting critical research. However, from our point of view, the critical foundations in many of the aforementioned lines of research as well as interlinkages could be further strengthened. For example, while important critical research is being done by investigating the interdependency between individual, social, and systemic developments in several lines of research, most investigations still tend to focus on momentary captures of psychological concepts. As the relation between individuals, societal and socio-economic structures, and respective change processes is highly dynamic, stronger investigating dynamic processes in

the biographies of individuals and their respective relations to their social and structural environments could further improve the understanding of this complex interplay. For this, investigating drivers of resistance and biographical fractions could be of specific interest. In this regard, researchers investigating psychodynamic mechanisms and social representations already provide fruitful insights. However, these research traditions could give even more weight to systematic investigations of (perceptions of) structural conditions and social critique. In the following section, we would like to take a step back and reflect upon how basic principles from critical social psychology could help linking and, partly, enhancing the critical work being done in the field.

Fundamental considerations on the importance of critical social psychology for environmental psychology

The studies listed in the previous section all have quite different theoretical foundations. Not all of them define themselves as critical, even though they broaden the spectrum of research in environmental psychology, in particular by also linking societal developments and social groups to individual behavior. In order to sharpen the notion of a "critical" approach in environmental psychology, we attempt to condense this rather broad understanding into three theses.

Thesis 1: There is a need for reflections on the image of humankind and the relationship between humans and the environment

Human behavior can be approached from a scientific perspective in different ways, for instance by focusing on attitudes, on ways of reacting to stimuli, or on different forms of social identity or social practice construction (Batel et al., 2016). This always implicitly implies a certain image of humankind and of the integration of people into society, even if this is not always reflected. In this context, especially with regard to numerous experimental designs, critical scholars point out the dangers of reductionist approaches that try to capture relationships in tangible causal models but fail to acknowledge the complexity of human action. When one focuses only on what can be clearly observed and measured, one quickly paints a distorted picture of social reality.

To illustrate this, let us refer to a quote by Fromm (1976, 1997, originally published in 1976) from the book *To Have or To Be*:

> The first requirement in the possible creation of the new society is to be aware of the almost insurmountable difficulties that such an attempt must face. The dim awareness of this difficulty is probably one of the main reasons that so little effort is made to make the necessary changes. Many think: 'Why strive for the impossible? Let us rather act as if the course we are steering will lead us to the place of safety and happiness that our maps indicate.' Those who unconsciously despair yet put on the mask of optimism are not necessarily wise. But those who have not given up hope can succeed only if they are hardheaded realists, shed all illusions, and fully appreciate the difficulties. This sobriety marks the distinction between awake and dreaming 'utopians' (Fromm, 1997, p. 141).

Fromm distinguishes here between a displayed optimism and an unconscious despair. This is based on a psychodynamically founded view of human beings, according to which we are not aware of certain feelings and drives of our actions and cannot easily become aware of them. From this perspective, optimistic attitudes that might be elicited from surveys using questionnaires can be understood as a mask and, at a deeper level, as an expression of hopelessness.

Regardless of whether and to what extent we are willing to follow Fromm's train of thought at this point, it becomes clear: Human perception and action cannot be understood independently of the image one forms of it – and this means that, also for environmental psychology, a reflection on both psychological and social-theoretical basic assumptions is required in order not to argue in a (post-)positivistic way. This includes reflections on what constitutes the environment, e.g., sense-making processes of the concept of *nature* (Castree, 2013) as well as consequences for political ecology and environmental governmentality (Luke, 2016).

Thesis 2: Human perception and action are to be understood from a dynamic perspective, which takes into account historical-cultural contexts, biographical socialization processes and the connection between past, present and future in the form of different narratives

None of us is timeless or spaceless. We are all bound up in certain historical contexts and societies with certain culturally shaped patterns of imagination. Even as scientists we cannot

free ourselves from this. This also applies to our personal development. We have become who we are today within the framework of a long-lasting biographical development, which, on the one hand, is connected with biological maturation and aging processes and, on the other hand, is to be understood as the result of socialization processes teaching us ideas of good and bad, right and wrong, etc.

Therefore, it is not only important for scientists in psychology and humanities to always reflexively question their own image of human beings and their social integration, but also to deal with how the people in the focus of an investigation see themselves and the world. How we perceive and act always depends on the subjective interpretation of our environment. Hence, people who are in the focus of investigations must not appear only as placeholders or as projection surfaces for assumptions of the scientists. However, the empirical examination of life trajectories, biographical decisions, and different basic assumptions in the population often comes up short. In this sense, Honneth (2007, p. 49) criticizes that the question of the motivational constitution of subjects should actually be at the center of sociocritical debate, but this is hardly the case in any approach in the interdisciplinary field of social criticism. Instead, it is mostly considered sufficient to expose grievances in society with regard to theoretically justified values or norms without facing the question why those affected do not problematize or attack such moral evils themselves (Honneth, 2007, p. 40).

From a dynamic perspective, it is important, for example, to investigate which socialization and politicization processes tend to precede environmentally harmful behavior, to what extent and in which contexts environment-related reflections become relevant to one's own actions in the first place, and how these relate to certain internalized value structures, the image of one's own past, and ideas of one's own biographical and social future.

Thesis 3: Environmental psychology should be seen in connection with social inequality and justice research

Environmental psychological issues should be addressed in conjunction with key global challenges. This means that especially social inequality research, poverty research, and the study of polarizations and divisions in societies have to be linked to environmental psychology, as well as the critical reflection of basic pillars of the contemporary world, such as the meaning of nationality and related limitations and possibilities of global action and public spaces of dialogue.

With strong ties to critical theory of the Frankfurt school, critical psychology particularly emphasizes the importance of social critique, and in this regard questions of power, context, or agency when looking at research contents and empowering approaches. Critical social psychologists (e.g., Tuffin, 2005) therefore point out that any contribution that relates individual action and experience to social contexts implicitly includes assumptions about society. The way in which any component of this society is described and explained is always also political, not least because it influences the self-image of its members. Directly connected to this are questions of justice as they are already clearly visible in the context of environmental psychology, for example, in the discourses on environmental justice and energy justice (see section "Alternative trends in current environmental psychology research fostering a critical perspective"). Perspectives of critical social psychology are crucial to follow processes of social transformation and to investigate how people deal with this situation and how this influences behavior, also on a group level (Kühn, 2015).

Critical environmental psychology from a life course perspective

In this section, we use examples from our own research practice to illustrate how approaches from a life course-oriented critical social psychology can be applied to and linked to questions of environmental psychology. In doing so, we simultaneously aim to illustrate, with a more detailed example, how environmental psychology as a whole can benefit from an expanded focus such as we have outlined in the previous sections.

A qualitative framework from a life-course perspective

Life course research combines two perspectives: On the one hand, it focuses on certain sections of specific biographies of individuals, for example, how entry into working life or the transition to retirement proceeds within study groups. On the other hand, the possibility spaces provided by social institutions are illuminated. This is based on the assumption that personal development trajectories can only be understood in the context of structurally shaped possibility spaces, such as those formed by the education and employment system. A life course-theoretical perspective stands out from approaches that speak rather vaguely of social community and associated culturally specific practices but do not further explore the significance of nation state and transnational regulatory systems. From a qualitative perspective, a particular focus is on the question of how and in what way different options to biographical trajectories are perceived and how this determines the everyday conduct of life. In the sense of critical research, this creates an approach to reconstructing mechanisms of constituting or reproducing social inequality structures. We can understand such qualitative life course research as a link between sociological and psychological approaches. Within the framework of psychology,

there is a large overlap with cultural psychology, which, for example in the tradition of Bruner (1991; cf. Chakkarath, 2017), strives to illuminate subjective construction of meaning and its connection in the form of narratives. However, in life course research, a dynamic perspective on biographies and their social-structural, institutional anchoring is even more explicitly defined as the starting point of research.

Especially qualitative approaches are of high importance for critical research as they enable us to trace symbolic constructions of reality, which are the foundations for the actions of individuals and the formation of social groups. Kühn (2015) developed the qualitative approach of a *life-course oriented critical social psychology*, which can be characterized by three basic requirements:

(a) *everyday orientation*,
(b) *elaboration of biographical processes*, and
(c) *reconstruction of modes of perception of social structure*.

(a) Everyday orientation

Important environmental psychological insights can be gained by addressing basic pillars and constitutional principles of everyday life. This links directly to key questions of environmental psychology on how and why people in everyday life contribute to the destruction of global ecosystems without consciously intending to do so and might be very helpful to identify new starting points for effective pro-environmental actions in everyday life (cf. section "Introduction").

A key advantage of qualitative everyday life-based research in environmental psychology is that it is able to capture ambivalences and contradictions. There are differentiated possibilities for tracing symbolic constructions of reality by individuals and groups by examining how people deal with uncertain, ambiguous, and contradictory initial conditions. We provide some examples of possible applications to questions from environmental psychology in **Figure 1**.

(b) Analysis of biographic processes

A major danger of primarily moment-based analyses is to view the lives of members of social groups predominantly as the consequence of individual decisions. A good example of this is the construct of free choice of occupation - in the sense that everyone is the architect of his or her own fortune and fate. Such a view ignores the fact that preceding family, school and occupational socialization processes are just as decisive for entering a profession as the institutional social-structural anchoring, shaping, and differentiation of certain occupational profiles, which were preceded by different historical development processes in different countries. Analogous considerations are also relevant for decisions that are the focus of environmental psychology, for instance regarding the use and purchase of means of transport in the context of research on mobility behavior.

From a biographical perspective, it can be reconstructed which conditions promote engagement in social movements and other forms of environmental activism (cf. section "Alternative trends in current environmental psychology research fostering a critical perspective"; see also Chawla, 1999; Matsuba and Pratt, 2013). The significance of the perception of justice issues in relation to social interaction as well as in connection with the environment can also be examined in connection with biographical planning processes and trajectories (cf. section "Alternative trends in current environmental psychology research fostering a critical perspective").

We provide some further examples of possible applications to questions from environmental psychology in **Figure 2**.

(c) Reconstruction of modes of perception of social structure

According to Kohli (1985, 1991), the life course can be understood as a social institution in the sense of a system of rules that structures central areas of life. By analyzing biographical processes and relating them to institutionally anchored structures, it is possible to understand how socialization processes lead to the formation of specific knowledge and value structures as well as habitualized ways of experiencing, perceiving, and acting, which ultimately form the basis for both self-limitations and the limited perception of possible options. Since individuals interpret the way people live together, interact with and feel connected to the environment in a specific way, it is important to make these patterns of interpretation the object of investigation by focusing on what images of social contexts and environment are drawn and for which social groups such images can be found and become meaningful. Exemplary questions could be: How do people explain social differences regarding the usage of alternative mobility options in societies, and which social groups are distinguished in this sense? To what extent is membership in different social groups constructed and what is this based on?

In section "Alternative trends in current environmental psychology research fostering a critical perspective," we pointed out the growing importance of multi-level studies for environmental psychology. This life course theoretical approach fits in with this, taking a microscopic view of subjective perceptions and biographical trajectories, but at the same time linking them to social institutions and structural conditions on a meso or macro level.

We provide some more examples of possible applications to questions from environmental psychology in **Figure 3**.

The conceptual approaches developed with the help of such a life-course oriented perspective are also relevant for environmental psychology. In the following, we will elaborate on this by drawing on examples from two of our own research projects.

The first project was about biographical trajectories in different training occupations. The project was part of a large-scale *DFG Collaborative Research Centre* that focused on the

EXAMPLES OF POSSIBLE ENVIRONMENTAL PSYCHOLOGICAL RESEARCH FIELDS FOCUSING ON EVERYDAY ORIENTATIONS

- Understanding the role of experiencing everyday contradictions between talk and action (e.g., in terms of climate change presented as a huge crisis requiring large-scale action in the public discourse vs. inadequate responses on different levels in the society, most prominently in policy-making and industry)
- Exploring the consequences of experienced emphasis on individual responsibility for mitigating ecological crises (resulting dilemmas and moral conflicts in everyday behavior)
- Exploring and revealing consequences of everyday uncertainties (e.g., uncertainties of climate implications when having to choose between regional food from a past season vs. imported food from the current season)
- Investigating conflicts between (seemingly contradicting) pro-environmental and pro-social motives/ actions/ policies (e.g., pricing policies fostering ecological products but thereby disadvantaging poorer households; access to 'greener' innovations/ products such as organic food, electric cars, and others predominantly chosen by richer households, investing time in pro-social vs. pro-environmental civic engagement)
- Investigating how people are dealing with uncertain, incomplete, or ambiguous information (e.g., electric cars being presented as pro-environmental technology and a sustainable solution to transport problems while at the same time, experts and newspaper articles may emphasize the CO_2-extensive production process or local environmental problems due to mining for lithium, cobalt, and rare earths as well as resulting social justice issues)
- Understanding the experience of conflicts caused by infrastructure design vs. divergent behavioral (or moral) expectations (e.g., car-friendly infrastructure design vs. pleas to cycle, walk, use more public transport; cheap and quick flights vs. pleas to take trains or buses)

FIGURE 1
Examples of possible environmental psychological research fields focusing on everyday orientations.

EXAMPLES OF POSSIBLE ENVIRONMENTAL PSYCHOLOGICAL RESEARCH FIELDS FOCUSING ON BIOGRAPHIC PROCESSES

- Understanding the genesis and interplay of conflicting motives (when pro-environmental motives are at stake with other motives such as social motives or norms, financial, time-related, convenience-related motives, joy, seeking new experiences, etc.); understanding prioritizations in the context of socialization and biographical backgrounds
- Engagement in pro-environmental or climate movements/ activism in the context of (shaping own) biographies
- Exploring resistance towards (lifestyle) changes, pro-environmental policies, or pro-environmental information/ communication in the context of socialization and biographical backgrounds
- Understanding emotional aspects such as climate anxiety, grief, place attachment from a biographical perspective (e.g., to emphasize such aspects when investigating questions of procedural justice or social equality in climate mitigation measures)
- Biographical pathways to identities based on engagement for the society and environment rather than arrangement with an inequal and unsustainable status quo

FIGURE 2
Examples of possible environmental psychological research fields focusing on biographic processes.

EXAMPLES OF POSSIBLE ENVIRONMENTAL PSYCHOLOGICAL RESEARCH FIELDS FOCUSING ON PERCEPTION MODES OF SOCIAL STRUCTURES
• Understanding which social groups in the society act (or can afford to act) pro-environmentally and how they perceive themselves and others: How do those who do not (or cannot afford to act) perceive the practices of groups showing pro-environmental behavior? • Investigating who engages in social movements and why: Which social groups are represented? Who is excluded and discriminated against? What role do problems such as post-colonialism/ whiteness, racism, sexism, etc. play for engagement in social movements? • Investigating the influential social group of policy makers: What characterizes this group? How homogenous is that group? How do policy makers re-construct the discourses around environmental issues; what meaning do they attribute to certain information or arguments and why? How do they make sense of the world; what are their norms? Who is excluded from that group and the perspectives and priorities predominant in that group? How is that group perceived by other social groups? • Exploring what different social groups associate with common terms such as *sustainability*, *climate change*, *environment*, *carbon emissions*: Which different meanings are ascribed? How do/ can members of different groups relate such terms to their own social practices? • Investigating the origins, meanings, and constitution of narratives of denial, scapegoatism, limited self-efficacy etc. in different social groups: How do people from different social groups view and deal with questions of (moral) responsibilities, ambiguities, and uncertainties (e.g., requirement of individual vs. political/ structural changes)?

FIGURE 3
Examples of possible environmental psychological research fields focusing on perception modes of social structures.

significance of status passages and risk positions in the life course. The surveys in the subproject *Status Passages into Employment* were carried out as a prospective longitudinal study in the late 1980s and 1990s, headed by Walter R. Heinz (Heinz et al., 1998; Kühn and Witzel, 2000; Schaeper et al., 2000; Heinz and Krüger, 2001)[4]. Kühn's research focused on how young, still childless adults dealt with the biographical option of starting a family and how this influenced biographical decisions, also in the professional sphere (Kühn, 2004). In accordance with a critical social psychological perspective, the project also dealt with unequal opportunity structures in different occupational environments and their significance for subjective modes of perception and action. Conceptually, we will present two models developed in the project in the following that we consider to be highly relevant for environmental psychological issues in section "Biographical Planning and Ambivalences": the model of *biographical planning* as well as a conceptual distinction for dealing with *ambivalence* in everyday life.

The second, more recent project dealt with identity constructions in the life course during the first year of the COVID-19 pandemic. During the project, qualitative interviews were conducted in Germany, Austria, and Brazil. The example we will provide in section "Changing meanings of consumption as identity work during the COVID-19 pandemic" refers to the Brazilian sub-study, for which more than 50 problem-centered interviews were conducted between April and May 2020 with Brazilians from different social groups (Kühn et al., 2020). Kühn et al. (2020) examined the significance of consumption for one's own identity work in times of social distancing. In this article, we will emphasize the results that show how the experience of the pandemic can contribute to a changed understanding of oneself and of consumption.

Biographical planning and ambivalences

There are considerable differences in the way young childless adults with a desire to have children deal with the option of starting a family. As part of the study *Status Passages into Employment*, young adults who had completed vocational training in various occupations were interviewed a total of three times at intervals of 2–3 years using qualitative guided *problem-centered interviews* (Witzel and Reiter, 2012) about their previous biographical trajectories, their current life situation, and their future life trajectories.

Critical social psychological research requires a concept of planning that is able to capture different forms of subjective engagement with biographical options without normatively tying them to particular notions of competence or rationality. Based on *Grounded Theory* (Strauss and Corbin, 1990; Witzel, 1996; Kelle, 2007) by the comparison of qualitative interviews, Kühn (2001, 2003, 2004, 2020b) developed the

4 In total, surveys were conducted in four waves at intervals of approximately three years between 1989 and 1997. In the fourth survey wave, only a standardized survey was conducted. problem-centered interviews with n = 91 respondents are available from the first three waves, who were interviewed at three points in time.

concept of *biographical planning*, which is particularly well suited to differentially capture the way individuals deal with structurally conditioned individual ambivalences and biographical uncertainty from an empirical perspective. The approach of biographical planning investigates which biographical goals actors develop and in which way individuals thematize biographical options, relate them to desired goals, and anticipate ways and activities to achieve these goals.

According to the developed typology, ideas oriented toward one's own biographical future differ, on the one hand, in how certain areas of life are linked as well as how the life courses of significant others are included (dimension *Interlinking*), how broad and clear the horizon of one's own ideas about the future is (dimension *Horizon*), and how ideas about the future develop, e.g., whether they remain constant over a period of time, fluctuate, etc. (dimension *Development*).

Figures 4, **5** describe the concept in detail.

Such an approach of biographical planning can be used for different environmental psychological questions that are related to biographical decisions. For example, planning processes for larger investments, e.g., in the fields of mobility or energy supply, could be linked to other areas of life and it could be differentiated which different planning modes exist and how they are related to different contextual conditions. It could also be examined how perceptions of climate crisis play a role on biographical planning processes for family formation (e.g., Schneider-Mayerson and Leong, 2020).

In the study *Status Passages into Employment* it became clear how significant ambivalent initial situations were for the everyday life and biographical course of young adults. Especially in view of structural obstacles to reconcile a successful professional career with high normative demands on one's own role as a parent, this created a tense initial situation for many childless persons, which at the same time represented a significant obstacle to long-term biographical planning processes. Once again, a heuristic model was developed from the comparison of the interviews on the basis of grounded theory, which distinguishes between (a) a permanent ambivalence existing over a longer biographical period and (b) an ambivalence experienced as highly tense with pressure to make decisions. The model differentiates between various biographical ways of dealing with these types of ambivalences (Kühn, 2004; see **figure 6**).

From the perspective of environmental psychology, structurally determined ambivalences are also important, for example with regard to ecological, economic and social aspects of sustainability as guidelines for decisions at the management level in organizations, but also with regard to possible expensive purchases or the decision to change one's own diet. Here, such a model and the associated knowledge about different biographical ways of dealing with things offer starting points for further research.

Changing meanings of consumption as identity work during the COVID-19 pandemic

From a life course perspective, the construction of identity has to be understood as an ongoing development process linked to one's own biography, which takes place as identity work in confrontation with the social world (e.g., Rosa, 1998; Keupp et al., 2002; Ehnis et al., 2015; Kühn, 2015, 2020a; Kühn et al., 2020). In line with this understanding, we can understand identity always as a specific subjective positioning that connects the experience of the present with interpretations of the biographical past and imagined future. The reconstruction of identity work may not be limited to the analysis of verbally articulated self-images and self-assessments of one's own person but has to focus on everyday life.

Especially in linking with approaches of the German sociologist Rosa (1998) and the social psychology group of Keupp et al. (2002), Kühn (2020a) proposed to differentiate identity work on three levels, summarized in the *normative ABC model of identity* (Kühn et al., 2020):

(A) Striving for *authenticity* and coherence: appreciating oneself, experiencing oneself as coherent and genuine, coming to terms with oneself.
(B) Striving for *belonging* and recognition: to experience oneself as integrated in society and as a valued part of a community.
(C) Striving for *control* and responsibility: being able to experience, shape and act effectively.

According to this model, identity work is a life long task, understanding identity as a dynamic construction that has to be re-established again and again in the course of life. The normative expectation is to constitute oneself in a specific way on three levels throughout life: to understand oneself as a coherent and unique person (authenticity), to understand oneself as a member of different groups (belonging), to make one's own decisions and in this way to exert a controlling influence on life (control). Identity work is It is connected with the effort to understand oneself and the world.

Within the research project *Identity constructions during the pandemics* (cf. section "A qualitative framework from a life-course perspective"), this normative ABC model of identity (Authenticity, Belonging, Control) forms a basis for investigating the symbolic significance of consumption for identity constructions.

The identity perspective has been used as theoretical ground to analyze and explore the symbolic meanings that individuals give to consumption and to understand how these meanings have changed during the course of the COVID pandemic. Kühn et al. (2020) compared the interviews in terms of references

BIOGRAPHICAL PLANNING		
DEVELOPMENT **Developmental course of considerations and ideas about one's own future**	**HORIZON** **Biographical planning horizon**	**INTERLINKING** **Interweaving biographical planning elements**
How do ideas about biographical goals and their realization develop in the biographical course?	How far into the future are biographical goals and ideas for their realization directed? In which accuracy / sharpness are biographical events anticipated?	How are ideas about the biographical future intertwined? What is the relationship between ideas about different areas, how are one's own ideas linked with those of significant others and existing social structures?

FIGURE 4
The concept of biographical planning (adapted from Kühn, 2004).

DIMENSIONS OF BIOGRAPHICAL PLANNING	
DEVELOPMENT	a) **Constancy** (until the end of the observation window or until realization) b) **Concretization** of formerly vague ideas c) **Break** with formerly concrete ideas d) **Vacillation/indecision** between different alternative conceptions e) An unplanned biographical event **contradicts** existing ideas and creates a completely changed biographical situation.
HORIZON	Ideas about the future can be rather vague or concrete, more short-term or long-term, more or less related to given social conditions (institutional reference). This applies to: I) Individual biographical goals and biographical goal structures. II) Goal-directed activities and anticipation of ways to reach the goal (modalities) III) Anticipation of the time span in which a biographical goal is to be achieved (schedules/timing) IV) Meaning of present goals against the background of basic ideas about stages of the whole life.
INTERLINKING	Interweaving of ideas about the future with regard to I) Relation of spheres of life II) Relation to biographical action and to the planning of significant others. Which biographical planning elements are intertwined in detail depends on the subject of the biographical planning under investigation.

FIGURE 5
Elaborations on the three biographical planning dimensions (adapted from Kühn, 2004).

to the importance of consumption for the construction of identity on the ground of a thematic analysis (Braun and Clarke, 2006), following a reflexive basic understanding (Braun and Clarke, 2019). The results showed a two-faced picture. On the one hand, consumption contributed to the reproduction of social inequality and even lead to polarizations within the Brazilian society becoming more significant. The researchers observed a reinforcement of social inequalities related to consumption, but also regarding the inclusion in the work sphere:

DEALING WITH AMBIVALENCES IN EVERYDAY LIFE	
SHORT-TERM **"HIGH VOLTAGE" AMBIVALENCE**	**LONG-TERM** **"UNDERLYING" PERMANENT AMBIVALENCE**
• Tipping effects cause decision • Pragmatic and spontaneous "creation of facts" • Giving up control: "letting fate decide" • Unplanned biographical developments occur (e.g., pregnancy, separation) • Attempts to postpone decision (transformation into long-term ambivalence)	• Keeping parallel options open as long as possible • Permanently enduring internal tension • "Sitting out": Waiting for changes to "happen on their own" • Permanent fading out of topics from own thinking processes • Disordered vacillation between different points of view • "Short-sightedness": Avoiding long-term plans • Repeated postponement of confrontations with significant other(s) • Postponing age ideals and/or deadlines • Searching for the loophole out of ambivalence • Efforts to reach a pragmatic compromise

FIGURE 6
Differences in dealing with short-term vs. long-term experiences of ambivalence in everyday life (adapted from Kühn, 2004).

THE NORMATIVE ABC OF IDENTITY WORK		
AUTHENTICITY	**BELONGING**	**CONTROL**
Striving for authenticity and coherence: appreciating oneself, experiencing oneself as coherent and genuine, coming to terms with oneself.	Striving for belonging and recognition: experiencing oneself as integrated in society and as a valued part of a community.	Striving for control and responsibility: being able to experience, shape and act effectively.
Engagement: Responsible and more reflected, sustainable way of consumption. Being part of a change that leads to a more reflexive and healthier lifestyle.	**Integration**: Solidarity rises, new groups – building the potential for a new understanding of one's own social role.	**Orientation**: Consumption as a means to feeling in control, to have choices, and to have an impact. Consumption as a means to dealing with own anxieties.

FIGURE 7
Analyzing the importance of consumption for the construction of identity during the COVID-19 pandemic in Brazil with the normative ABC model of identity (adapted from Kühn et al., 2020).

Whereas for many rather poor people in Brazil, the possibility to work even within the pandemic is a matter of survival, as they need the income to buy food, for richer people there is scope and opportunity to reflect on one's own role in society free from existential constraints. These findings show the extent to which normalcy continues to be unjust during and after the pandemic (Kühn et al., 2020, p. 809).

On the other hand, Kühn et al. (2020) were able to analyze that, during the pandemic, people also reflected on their consumption and made efforts to change their own consumption behavior. Furthermore, consumption could also contribute to providing orientation, to feeling like an integrated member of a community, and to strengthening one's own commitment. **Figure 7** provides an overview of these findings.

Kühn et al. (2020) see hopeful signs in their findings from a critical social psychological perspective, an assessment that is also relevant for environmental psychology:

These include the emphasis on the responsibility as a consumer for sustainable social development as well as the experience of solidarity and the formation of new identities,

which could form the basis for future political endeavors. Different modes of consumption are possible, e.g., a reflexive consumption of regional products in order to strengthen and promote regional traders, from a social identity perspective also in order to feel part of the community, not feeling isolated, but as a productive piece of a whole (Kühn et al., 2020, p. 808).

The example of the changing meaning of consumption during the pandemic shows how fruitful it can be also for other areas of environmental psychology to address them from a life-course identity perspective, such as regarding the meaning of a vegan diet, the study of biographical turning points, and related decisions to change one's actions and to engage in social movements.

Conclusion

Environmental psychology has a long tradition and is a recognized research discipline that is also valued in practice. In view of climate change and discussions about a sustainable design of social transformation processes, for example, in connection with the digitalization of everyday worlds, the importance of research in environmental psychology is becoming increasingly apparent to wider circles. It seems all the more important to us that environmental psychology opens itself even more to exchange and discourse with representatives and approaches of other disciplines and that promising joint projects emerge from the contact that link individual behavior with reflections on social development.

In this respect, many promising projects in environmental psychology can already be identified, some of which we have listed during the course of this paper. At the same time, given the complexity of environmental psychology issues, we see a certain danger of fragmentation that could lead both to promising projects not getting the attention they deserve and to more work being done side by side rather than together.

In this respect, a shared self-understanding in terms of a critical environmental psychology would be helpful. We have developed points of reference for this in the article, which we take to be a departure into discourse rather than the end point of such discussions. In our understanding, a critical approach is characterized in particular by its reflexivity, dynamic understanding, and questioning of power and inequality structures as a milestone on the way to a more just and sustainable world. As an example of a critical understanding in this sense, we have discussed the possibilities of a qualitative life course approach.

In this sense, environmental psychology would be more concerned with strengthening a socialization perspective that focuses on identity work in confrontation with social structures and thus, in particular, allows conclusions to be drawn about how partly contradictory, ambivalent, or ambiguous normative social expectations are reflected in everyday life and unequal biographical life paths. Qualitative research in particular is suited to show, from a critical perspective, how habitualized practices, symbolic, and narrative constructions of reality are linked to social inequality as well as suboptimal behavior patterns from an environmental sustainability perspective.

Conceptually, the approach of the normative ABC of identity work, biographical planning, and the distinction between two biographically relevant forms of ambivalence exemplified how such research can be made fruitful for central environmental psychological questions. This preliminary conceptual work provides a foundation that can be used for numerous future projects.

We make no claim to completeness with this article, but see it as an impulse. In keeping with our reflexive understanding, we believe it is important that environmental psychologists also reflect on what constitutes its own discipline and how research in the field can be meaningfully expanded and supplemented.

Following on from this, we would like to issue a "call for action": We would be delighted if colleagues expressed interest in developing a comprehensive critical research agenda and further contributing to building a global research network and critical community together.

Especially in view of numerous global challenges such as climate change and divisions within and between societies that shape our contemporary everyday life, we consider it one of the most important tasks of environmental psychology to make contributions that deal with transformation and can contribute to shaping sustainable social and structural change and clearly identify associated dangers.

Author contributions

TK and SB contributed to the conceptualization of the manuscript, wrote sections of the manuscript, reviewed and edited the original draft, and approved the submitted versions. TK was responsible for funding acquisition and supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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A systematic review to assess the evidence-based effectiveness, content, and success factors of behavior change interventions for enhancing pro-environmental behavior in individuals

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To reduce global greenhouse gas emissions in order to limit global warming to 1.5°C, individuals and households play a key role. Behavior change interventions to promote pro-environmental behavior in individuals are needed to reduce emissions globally. This systematic literature review aims to assess the a) evidence-based effectiveness of such interventions and b) the content of very successful interventions without limiting the results to specific emitting sectors or countries. Based on the "PICOS" mnemonic and PRISMA statement, a search strategy was developed, and eligibility criteria were defined. Three databases (Embase, PsycInfo, and Web of Science) were searched to retrieve and review potential literature. As a result, 54 publications from 2010 to 2021 were included in the analysis. The results show that most interventions only have small positive effects or none at all. A total of 15 very successful interventions focused on the sectors of mobility, energy, and waste and incorporated improved (infra-) structures, education, feedback, enablement or made the sustainable option the default. Six evidence-based recommendations for content, timing, and setting are deducted and given for interventions on enhancing pro-environmental behavior (PEB). In summary, although the various interventions and intervention types to promote PEB differ in their effectiveness, very successful interventions have common elements. Future research should focus on high-/low-impact and high-/low-cost behavior to develop interventions that aim at high-impact but low-cost behavior changes, or avoid low-impact but high-cost behavior.

KEYWORDS

behavior change, intervention, pro-environmental behavior, climate change, sustainability, environmental psychology

Introduction

To reduce global greenhouse gas (GHG) emissions in order to limit global warming to 1.5°C, countries are now committed through agreements [e.g., 2030 Agenda for Sustainable Development (United Nations, 2015)] to work toward implementing sustainable living and consumption. For this purpose, individuals and households play a key role in climate-friendly transformations: "All households will need to play a part in this transformation" (HM Government, 2009, p. 82). The key focus is narrowed to pro-environmental behavior (PEB), which means "behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world" (Kollmuss and Agyeman, 2002, p. 240). To proactively take effective actions to minimize negative environmental impacts, a growing number of climate change experimentation and intervention studies to enhance PEB are conducted (Castán Broto and Bulkeley, 2013).

Peer-reviewed papers that describe tested interventions are included. The value added by this work is that the interventions and their contents are described and compared to each other in a comprehensible and novel way.

Behavior change models

Behavior change is an important research topic in psychology, health, and sustainability sciences. Consequently, various models to effectively change behavior have been developed and discussed (Fishbein and Ajzen, 1975; Schwartz and Howard, 1981; Prochaska and DiClemente, 1984; Heckhausen and Gollwitzer, 1987; Bamberg, 2013; Steg et al., 2014). The most commonly used models to describe and encourage PEB (Hellbrück and Kals, 2012; Bamberg, 2013) are the theory of planned behavior [TPB, (Ajzen, 1991)] and the norm activation model [NAM, (Schwartz, 1977)]. However, both have been criticized for being oversimplified, too cognitive, and having a high empirical intention-behavior gap (Lewin et al., 1944; Hellbrück and Kals, 2012; Bamberg, 2013).

To address this criticism, the transtheoretical model (TTM, [Prochaska and DiClemente, 1984)] was used (mostly in the health domain but also in the sustainability context) to describe, explain, predict, and modulate intentional behavior change. The model consists of behavior change stages that need to be completed but also allows for several relapses to earlier stages before permanent behavior change is achieved. According to the TTM, interventions first need to focus on informing about and enhancing the positive aspects of behavior change to support the first stages and subsequently empower and reward behavior change during the last stages (Bamberg, 2007; Andersson et al., 2018).

However, TTM only considers intrinsic factors, which is why Gifford and Nilsson (2014) suggested a more complex expansion. The model of pro-environmental behavior that Kollmuss and Agyeman (2002) designed, specifically aimed at PEB, is an extended and complex model including external factors and feedback slopes. Their model was influenced by Fliegenschnee and Schelakovsky (1998), whose work was based on Fietkau and Kessel (1981). Both external factors (infrastructure, political and economic situation, etc.) and internal factors (personality traits, value system, etc.) influence PEB and are in return influenced by the individual's PEB—directly in the case of internal factors, and indirectly concerning external factors (Kollmuss and Agyeman, 2002). This complex model allows for various possible barriers to directly influence an individual's PEB. With the inclusion of external possibilities, the model clearly shows that individual behavior is only possible within a social framework, thereby limiting behavioral change. Interestingly, environmental consciousness, which belongs to the internal factors, consists of knowledge, emotional involvement, and values/attitudes, which can also serve as barriers and lead to negative feedback slopes (Kollmuss and Agyeman, 2002). This model was discussed and used as a theoretical basis in case studies, e.g., Stoll-Kleemann (2019) adapted this model to the practical issue of ocean-related PEB and thereby proved its applicability (Jensen, 2002; Payne, 2002).

In summary, even this modern, more specific, and extended model leads interventions to aim at increasing the knowledge base and both actively and emotionally involve individuals. Therefore, the models suggest that interventions should target several factors at once and not just gradually one after the other.

Pro-environmental behavior change interventions

Abrahamse already listed well-used behavior change intervention types (Abrahamse, 2019), which allow researchers to categorize typical interventions as (1) providing (a) general or (b) tailored information/education; (2) providing feedback; (3) goal-setting/implementation intention and commitment; (4) nudging; (5) social influence, e.g., block leader, social modeling, social norms, or social marketing using message framing; (6) gamification; (7) policies, e.g., pricing or regulatory changes; and (8) structural measures, e.g., changing infrastructures.

According to Abrahamse (2019), the general approach to changing behavior is to provide information to enhance the knowledge base for decision-making. Information can either be general or tailored to specific situations or persons.

Giving individuals insights into their performance and the outcome of a certain task is called "feedback." Consequently, feedback is used to increase a person's understanding of the relationship between performing a certain task (e.g., turning off appliances when not in use) and achieving a certain outcome (e.g., saving energy) (Cornelius et al., 2014; Abrahamse, 2019).

Additionally, setting a goal to achieve something (e.g., reduction of meat consumption in kg/week) or performing a task in a certain time frame can encourage behavior change. To support such goals, pledges can be made. These commitments can either be made verbally or in writing, and in private or public (Cornelius et al., 2014; Abrahamse, 2019).

Another intervention category is "nudging," which as the word implies is a soft nudge toward behavior that is more desirable but not fully integrated into everyday life. Nudging interventions use small changes to the environment to influence the individual's decisions (Kurz, 2018; Abrahamse, 2019).

Furthermore, other people can also influence individuals and their behavior. For example, by observing the behavior of other people one can deduct what behaviors are expected from an individual in a certain situation and use it as a benchmark for one's own behavior. Another example is that social networks can be used to disseminate information, or that already familiar individuals can serve as role models, e.g., "block leaders." Additionally, techniques like social marketing use and implement messages in specific ways to influence how people understand and respond to an issue, e.g., by triggering certain emotions or linking behavior to certain values that a person has (Schultz et al., 2007; Dolan et al., 2012; Abrahamse, 2019).

Interventions using typical game elements—like competitions, challenges, quests, and the possibility to earn badges/points and be compared to others *via* a leaderboard—outside of gaming contexts belong to the category of "gamification" (Cellina et al., 2019).

Another way to influence behavior is through policies. Policies are rules that people who belong to the area/group to which this policy applies have to adhere to. These policies can be local, national, or global.

Lastly, structural measures, which are mostly technological interventions, can be used to change the environment and encourage PEB. This could, for example, entail turning a street into a cycle and walking area while prohibiting cars, or installing water- and energy-saving appliances in a building.

In addition to the categorization made by Abrahamse (2019), Gardner and Stern (1996) differentiated between four major types of interventions: religious and moral approaches, education to change attitudes and provide information (similar to Abrahamse's "providing information"), changing the material incentive structure of behavior (similar to Abrahamse's "nudging") and other types of rewards or penalties (similar to "structural measures"). They concluded that all of these intervention types can change behavior if they are executed carefully. In general, however, moral, and educational approaches, as well as incentive- and community-based approaches, were less effective. The most successful intervention types in the study by Gardner and Stern (1996) were combinations of various intervention types.

Recommendations made by Gardner and Stern (1996) as well as Stern (2000) include firstly identifying the target behaviors that have a significant impact on the environment. As a next step, the responsible actors and actions of that behavior should be identified. Afterward, the full range of causal variables needs to be considered. Also, the possible relevance to the target behavior from the actor's standpoint should be understood. Lastly, including the participation of representatives of the population whose behavior is to be changed enables interventions to become promising behavior change strategies (Gardner and Stern, 1996; Stern, 2000).

The most common methods to measure interventions' effectiveness include (a) reduced GHG emissions, (b) economic benefits, or (c) other societal gains. However, the (d) impact of interventions also needs to be considered by categorizing the "impact" as high or low based on the share of the emitting sector. The main sectors directly emitting anthropogenic GHG by economic segments are energy, i.e., electricity and heat production (25%), industry (21%), and transport/mobility (14%) as of 2010 (IPCC, 2014, p. 47). For individuals, the main GHG emitting sectors differ slightly from the economic range: mobility (34%), food (30%), housing (including electricity and heating) (21%), and others incl. consumption (15%) (Dubois et al., 2019). Additionally, the success of interventions can be measured as short vs. long-term behavior change and commitment.

However, Wynes et al. concluded that "it is unlikely that researchers have reached consensus on the most effective interventions" (Wynes et al., 2018, p. 5). Especially theoretical frameworks reach their limits when individuals deviate from rationality in their decision-making and resulting behavior (Frederiks et al., 2015). Consequently, empirical evidence is needed to identify effective behavior change interventions. While reviews regarding behavior change interventions exist (Abrahamse et al., 2005; Fisher and Irvine, 2016; Staddon et al., 2016; Andersson et al., 2018; Iweka et al., 2019; Stankuniene et al., 2020), these mostly (a) have used unsystematic or incompletely described methods, and/or (b) were limited to only one emitting sector or targeted level, i.e., (a) individual, (b) community, or (c) policy (intervention applies to whole business chain, or country-/union-wide). According to the targeted level, interventions can aim at changing (a) an individual's PEB, (b) a community's PEB, e.g., by changing infrastructure or social factors, or (c) policy-based PEB, e.g., prohibiting behavior with negative environmental impacts like overexploitation, or constituting/subsidizing PEB by replacing harmful technology.

A careful review of the literature indicates that the description of successful interventions' contents and/or combinations of interventions regardless of the emitting sector or targeted level do not appear to have been part of any reviews to date. For example, Stankuniene et al. (2020) conducted a review on behavioral barriers in households focusing on energy. Although the barriers are exhaustively defined, the content of the reviewed studies was not described in detail. Nisa et al. (2019) reviewed randomized controlled trials (RCT) on

behavior change and found no evidence of sustained positive effects regarding PEB once the intervention ended. However, the reviewed studies seemingly only used single intervention types and, therefore, combinations of intervention types are not part of the review. Osbaldiston and Schott (Osbaldiston and Schott, 2012) did investigate combinations of intervention types and their effectiveness. However, they conclude "[…] that there is no one treatment (a 'silver bullet') that is highly effective across all the possible PEB" (Osbaldiston and Schott, 2012, p. 280). Nisa et al. mentioned that "The content of interventions needs to be tested more precisely because a large proportion of interventions to date implements bundles of stimuli from which the identification of the key driver of effectiveness is difficult to grasp" (Nisa et al., 2019, p. 9).

This paper aims to close the research gap by systematically reviewing and analyzing the possible level of effectiveness of PEB interventions and the content of successful interventions based on evidence from the literature without limitation to only one specific GHG emitting sector or specific geographical units, e.g., countries. Using this approach, important implications for developing effective and appropriate interventions can be derived. Similar to the "what works" agenda in UK science-policy circles, this paper focuses on identifying and ranging effective, i.e., "successful," intervention methods to provide recommendations concerning intervention development (West et al., 2019).

To assess the evidence-based effectiveness of behavior change interventions for enhancing PEB in individuals, this paper focuses on the following research questions:

1. Do effective interventions exist that increase PEB?
2. Do intervention types differ in their effectiveness to promote PEB?
3. Can recommendations be derived from evidence on how interventions for enhancing PEB should be designed and implemented?

Materials and methods

This paper used a broad scope review, i.e., it is designed as a comprehensive summary of evidence to explore the consistency of the findings to date and to compare the impact or effectiveness of different interventions. Thus, it allows for generalizability across interventions.

Systematic search methodology

Review methods developed within medical research, e.g., the Cochrane Handbook for Systematic Reviews of Interventions (Higgins and Green, 2019) as well as the PRISMA statement (Moher et al., 2009) can readily be applied to the sustainable research field and were used for this review. The aim is to enable others to reproduce the results, and thereby make the review more usable for decision-makers.

TABLE 1 Search terms for the systematic literature review using the "PICOS" mnemonic.

PICOS element	Search terms
(A) Problem	Carbon footprint; CO*Fu*abdruck; green house gas; GHG; Treibhausgas; emission
(B) Intervention	Experiment; intervention; behavio* change; Verhaltensänderung; Verhaltensveränderung; household decision-making; transition; value system*; Wert*system; habit; Gewohnheit; dissociation; dissonance; Dissoziation; Dissonanz
(C) Comparisons	Energy; energy consumption; Energie; Energieverbrauch; mobilit*; transport; air travel; travel decision; Ernährung; diet
(D) Outcomes	Motivation; self-efficacy; self-identity; *environmental *identity; Identität; pro-environmental behavio*; environmental awareness; sustainab*; mitigation; adaptation; sufficiency; Nachhaltigkeit*; Anpassung; Suffizienz; low*cost; high*cost; incentive; income; Anreiz; Einkommen
(E) Setting	Climate change; climate crisis; Klimawandel; Klimakrise; environmental change; planetary boundaries

*Is used as a wildcard and stands for any character(s) that might occur enabling the database query to search for words with different possible spellings, e.g., "behavior" in British or "behavior" in American English.

For this purpose, the "PICOS" mnemonic was used to formulate the database query. PICOS is an acronym for the elements Problem/Population, Intervention, Comparison(s), Outcome(s), and Setting (Moher et al., 2009). The review's PICOS set the inclusion and exclusion criteria of PEB-intervention studies.

To capture the quite dispersed range of literature in this field, the queries used in the search strategy were chosen to cover the three main GHG emitting sectors (mobility, energy/housing, food) responsible for 56–85% of individuals' GHG emissions (Bundesministerium für Umwelt, 2018; Dubois et al., 2019). This made the search as specific as necessary while being as generic as possible. However, to not limit this review to predefined emission sectors but also include uncommon interventions or interventions aiming at other emission sectors, publications with data of PEB-interventions regarding other sectors, e.g., consumerism, were also considered eligible and included in this review if such were identified by the search queries.

The already defined search terms (see Table 1) within a PICOS element were linked *via* the Boolean operator "OR." This means that a resulting publication should at least contain one search term per PICOS element. The elements A to E were connected with AND operators.

Comprehensive literature searches to identify eligible intervention studies were conducted on 1 April 2020 using multiple academic online databases and their database-specific syntaxes namely, Embase, Web of Science, APA PsycInfo, APA PsycArticles, and Psychology as well as the Behavioral Sciences Collection *via* EBSCOhost (see Supplement "Database Searches," Supplementary Tables 1–3). This comprehensive literature search was continuously updated until 1 March 2022 using search alerts for the respective databases. Only relevant and accessible publications were retrieved from the search alerts and included in the category "identified through other sources" to not compromise the reproducibility and results of the original systematic literature search.

Eligibility criteria

The eligibility criteria are based on the PICOS elements of the review question plus a specification of the types of studies that have addressed these questions.

Publications were considered eligible when published in English or German, from 2010 on, and available in full text. The included publications should be peer-reviewed and needed to be a study of a behavior change intervention in relation to PEB, which reported on outcomes generated through the intervention. The intervention design should allow for effects to be measured either compared to a baseline (pretest/post-test design) or a control group. Eligible studies could report on interventions in any country and for any emission sector or targeted behavior, as long as the methodology and outcomes are described in a comprehensible manner without apparent quality problems. Existing reviews were included if they provided information on the study population, intervention methodology, and outcomes of at least one intervention study that was otherwise unavailable in full-text to the authors.

Publications were not considered eligible when they focus on (a) models, e.g., to compute savings or possible scenarios; (b) (discrete choice or framing) experiments analyzing the intention or willingness of participants only; (c) measuring or quantifying GHG emissions without intervention; (d) assessing technical solutions only. Whilst technologies and intention-based experiments create a new context in which behavior change can take place, these do not aim to induce changes in behavior. Consequently, such publications were not considered in this review. Excluded papers from full-text screening including the reason for exclusion can be found in the Supplementary material under "Excluded Publications".

Selection process

The titles and abstracts from the preliminary search were retrieved and reviewed for relevancy and the full-text articles of relevant studies were retrieved, if possible, for further review. The retrieved full-text articles were assessed for inclusion based on the criteria listed above and inconsistencies were resolved between the authors during all review phases. A table summarizing the included studies was prepared (see Table 2), with the following segments: country of conducted intervention, GHG emitting sector the intervention is targeting, type and description of intervention approach, the effectiveness of the intervention, and targeted level.

Effectiveness is reported in Table 2 as a positive value when the intervention group changed its behavior to increased PEB compared to baseline values or a control group (+)—or in case of significant increase (++)—and a negative value when the intervention led to decreased PEB (-). In case the intervention did not affect actual behavior the intervention is rated with an "o."

Reducing risk of bias

To reduce the risk of overestimating the effects of interventions, intervention studies are only considered once in the analysis. This means that all relevant publications of interventions are included in the quantitative results of the literature search. However, if they are also part of a review that is also included in the analysis, they will only be considered as part of the review. Consequently, these publications will be included in Table 2 with a respective remark and only reviewed as full-text to ensure the extraction of the most information possible.

Results

The database searches resulted in a total of 3,174 publications using Embase ($n = 162$), APA PsycInfo, APA PsycArticles and Psychology as well as the Behavioral Sciences Collection *via* EBSCOhost ($n = 79$), and Web Of Science ($n = 2{,}933$) (see Supplementary material "Database Searches"). Additionally, search alerts were used from 2 April 2020 until 1 March 2022 to identify further publications. These search alerts suggested a further 1,657 publications (Embase $n = 91$, EBSCOhost $n = 19$, Web Of Science $n = 1{,}547$), including duplicates, resulting in three publications, which were included as "identified through other sources" in this review. After screening and assessing the full texts for eligibility, 54 publications were included in this review (see Figure 1). All publications were published in English, dating from 2010 to 2021. As depicted in Figure 2, four of the described studies in these publications were conducted in Australia, one in New Zealand, three in Africa (one each in Nigeria, Ethiopia, and South Africa), and six in Asia (one each in China, India, Singapore, and Taiwan, and two in Japan), 35 in North America (USA $n = 32$, Canada $n = 3$), and two in South America

TABLE 2 Summary of included publications.

Publication	Country	Sector	Intervention type	Effectiveness (++ / + / o / –)	Level
Aiken (2018)	UK	Energy	Social influence *via* motivational interviewing, energy audits, and reimbursement	+	Community
Araña and León (2016)	Spain	Mobility and consumption (tourism)	Social influence *via* message framing, time pressure, or pricing policy—RCT using a field experiment with fully consequential choices	+	Policy
Asensio and Delmas (2015) (in Wynes)	See Wynes (USA)	See Wynes (energy)	See Wynes (information and feedback campaign integrating social marketing messages and non-price incentives—RCT incl. survey data)	See Wynes (+ overall, ++ in subgroup with children)	See Wynes (individual)
Barata et al. (2017)	Portugal	Energy and water	Information and feedback campaign—controlled trial incl. survey data	+	Individual
Beitzen-Heineke et al. (2017)	Germany, Austria, Italy	Consumption	Structural measures—zero packaging grocery stores as an alternative retail concept	+	Community
Benka-Coker et al. (2018)	Ethiopia	Energy	Structural measures—provision of technology, i.e., less GHG-emitting ethanol cookstoves in (a) a Refugee program and (b) low-income urban intervention	+	Community
Börner et al. (2015)	Netherlands	Energy	Information campaign	+	Individual
Bohdanowicz et al. (2011)	Europe	Energy, water, waste	Policies regarding the sustainability of a hotel chain	+	Policy
Boso et al. (2019)	Chile	Energy	Structural measures—governmental replacement program to replace 39,000 wood-burning stoves in the municipalities of Temuco and Padre Las Casas by 2020	+	Policy
Brand et al. (2014)	UK	Mobility	Structural measures—new walking and cycling infrastructure	o	Community
Büchs et al. (2018)	UK	Energy	Tailored information trial using a carbon calculator interview (RCT)	o	Individual
Carrico and Riemer (2011) (in Staddon)	See Staddon (USA)	See Staddon (energy)	See Staddon (General information, peer education, and feedback)	See Staddon (+)	See Staddon (community)
Casals et al. (2020)	UK	Energy	Gamification	+	Individual
Cellina et al. (2019)	Switzerland	Mobility	Gamification including feedback and social influence (comparison); RCT study design	o (+ in systematic routes in one region)	Individual
Chiu et al. (2020)	Taiwan	Energy	Feedback and social influence (persuasive technology, comparison with peers, and rewards)	+	Individual
Cornelius et al. (2014)	USA	Energy, food, mobility	Information, goal setting, social influence, gamification, feedback in a classroom setting; cluster-RCT study design	+	Community
Damsø et al. (2017)	Denmark	Energy	Policies and structural measures like renewable energy provision as a default for a municipality	++	Policy
Dawkins et al. (2019) (Review)	OECD-countries	Consumption	Policies and structural measures	o /+ (depending on the study)	Policy
Dowd et al. (2012)	Australia	Energy	Social influence incl. tailored information, goal setting, and feedback for low-income participants	++	Individual
Fisher and Irvine (2016) (Review)	Netherlands ($N = 1$), UK ($N = 3$)	Energy	Social influence incl. information, commitment, and feedback	++	Individual

(Continued)

TABLE 2 (Continued)

Publication	Country	Sector	Intervention type	Effectiveness (++ / + / o / –)	Level
Hall et al. (2013)	Australia	Energy	Social influence incl. general information	+	Individual
Hammed et al. (2018)	Nigeria	Waste (recycling)	Social influence incl. practical education	++	Community
Happer and Philo (2016)	UK	Not specified	Social influence *via* media messages	o	Individual
Hoicka et al. (2014)	Canada	Energy	Policies and structural measures—provision of audit/tailored information and technical solutions/retrofit improvements for house owners (incl. reimbursement in programs 2 and 4)	++	Individual
Howarth and Roberts (2018)	UK	Energy	Policies and structural measures—provision of audit/tailored information and suggestions for technical solutions/retrofit improvements to households incl. governmental incentive structure (paying back a loan attached to the house *via* energy bill)	o	Individual
Howell (2011)	UK	Energy, food, mobility	Social influence *via* message framing using a movie	o	Individual
Howell (2012) (in Fisher)	See Fisher (UK)	See Fisher (energy)	See Fisher (Social influence incl. information, commitment, and feedback)	See Fisher (++)	See Fisher (individual)
Iweka et al. (2019)(Review)	See Fisher, others not specified	Energy	General information (energy labels, prompts), tailored information (energy audits), social influences (norms, block leader), goal setting and commitments, feedback, gamification, incentives	o (general information, incentives) + (tailored information, norms) ++ (commitments, goal setting, feedback, gamification, block leaders)	Individual, community
Jacobsen et al. (2013)	USA	Energy	Policies and structural measures—state-sanctioned, green-electricity options program to fund the development of renewable energy systems incl. commitment ("municipality pledge") and earning points for residential signups to earn incentives for the community (solar panels)	++	Individual, community
Jorgensen et al. (2021)	Australia	Energy	Information—two experiments with students in residential halls (as consumers, who are not billed for energy consumption) with information about reducing energy consumption during the peak demand period—additionally, experiment 1 used normative feedback, and experiment 2 used normative feedback and prompts/reminder notifications at different time points, RCT study design.	+	Individual, community
Keall et al. (2015)	New Zealand	Mobility	Structural measures—public investment in infrastructure for walking and cycling plus social influence (social marketing) compared with a control group (two other cities with similar characteristics)	+	Individual

(Continued)

TABLE 2 (Continued)

Publication	Country	Sector	Intervention type	Effectiveness (++ / + / o / –)	Level
Kelly et al. (2013) (Review)	Not specified	Food	Social influence, goal setting, feedback, general information; six studies were RCTs	o/+ (depending on the study, changes were not maintained at follow-up)	Individual
Kurz (2018)	Sweden	Food	Nudging (changing menu order and visibility of dish—vegetarian dish was moved to the top of the menu and visible at the point of decision-making) compared to control restaurant with similar characteristics	+ (positive change maintained even 13 weeks after intervention)	Individual
Laakso (2017)	Finland	Mobility	Social influence and commitment—household has to sell one car and receives free travel cards for local (bus) services incl. survey data and follow-up	++ (the positive change was mostly maintained at follow-up)	Individual
Largo-Wight and Wight (2013)	USA	Waste (recycling)	Structural measures and nudging—adding indoor opportunities to recycle cans and bottles compared with only-outdoor-receptacles control	++	Individual
Malan et al. (2020)	USA	Food	Education—one-unit seminar course "Foodprint seminar" at universities regarding food systems and sustainability incl. surveys to assess climate change self-efficacy amongst other things	+	Individual, community
Marchand et al. (2015)	UK	Energy	Policies and structural measures—provision of audit/tailored information and suggestions for technical improvements to households incl. free of charge installation	+	Individual
Matsui et al. (2014)	Japan	Energy	Feedback on electricity usage and general information compared to control	o (- for one household because of their changed circumstances during intervention)	Individual
Meloni et al. (2011)	Italy	Mobility	Policies with an activity-travel-measurement app and personal weekly maximum amount of personal carbon emissions (cap) incl. commitment and general information	+	Individual
Morris et al. (2016)	Australia	Energy	Policies and structural measures—solar city project; social influences (in-home energy assessment incl. tailored information and free-of-charge replacements/installations), commitment, gamification (competition), and residents asked to host solar panels of power providers on their roofs to reduce emissions without direct benefit	++	Individual, community
Mrkajic et al. (2015)	Serbia	Mobility	Structural measures—providing a secure bicycle parking facility incl. survey data, comparison with control	+	Individual
Nishida et al. (2016)	Japan	Energy	Policies—Cap-and-Trade Program for energy consumption-related emissions in buildings incl. goal setting and social/organizational approaches (performance disclosure and certification system)	++	Policy

(Continued)

TABLE 2 (Continued)

Publication	Country	Sector	Intervention type	Effectiveness (++ / + / o / –)	Level
Ornaghi et al. (2018)	UK	Energy	Social influence—motivating messages incl. general or tailored information about window management during the heating season compared to control with similar characteristics	+ (changes maintained at follow-up for tailored information)	Individual
Quested et al. (2013)	UK	Food	Social influence incl. education—Love Food Hate Waste messages, recipes, tips, and training to encourage the use of food rather than a reduction in waste	+	Individual, community
Reeves et al. (2014)	UK	Energy, food, mobility, consumption	Social influence—Support for community-led actions and initiatives	+	Community
Revell (2014)	UK	Energy	On-site energy audits incl. tailored information, installing easy measures and suggestions for further technical improvements for households plus survey data	+ (but no actual behavior change)	Individual
Ro et al. (2017) (in Iweka)	USA	See Iweka (energy)	See Iweka (Gamification incl. online game, receiving credits for completed tasks, team competition, leaderboard)	See Iweka (+) (+ and positive behavior changes maintained at follow-up)	See Iweka (individual)
Ruiz-Tagle and Schueftan (2021)	Chile	Air pollution	Nudging and information—information sign as a magnet above the stove's setting, including visits/phone calls to households; RCT incl. survey data)	+	Individual
Schultz et al. (2015)	USA	Energy	Social influence (social marketing)—in-store and school-based events to make people purchase and install LED light bulbs, incl. commitment, education, and rebates compared to control stores	+ for electricity consumption behavior change	Individual
Sintov et al. (2016)	See Wynes (USA)	See Wynes (energy)	See Wynes (Gamification [competition with incentives], general information, and feedback on electricity usage plus survey data)	See Wynes (+)	See Wynes (individual)
Staddon et al. (2016) (Review)	USA ($N = 10$), UK ($N = 5$), Netherlands ($N = 3$), Canada ($N = 2$), Sweden ($N = 1$), and Singapore ($N = 1$)	Energy ($N = 22$)	Social influence *via* volunteers in workplace, meetings, general or tailored information and education, feedback, goal setting, gamification (competition and challenges), structural measures (e.g., building renovation)	++ (eight studies), + (12 studies)	Individual, community
Wang and Boggio-Marzet (2018)	Spain	Mobility	Education—eco-driving training to apply emission and fuel consumption-reducing techniques	+	Individual
West et al. (2019)	UK ($N = 1$), Sweden ($N = 1$)	Energy, food, consumption, mobility	Tailored information using a Carbon Footprint Calculator	o	Individual

(Continued)

TABLE 2 (Continued)

Publication	Country	Sector	Intervention type	Effectiveness (++ / + / o / –)	Level
Wynes et al. (2018) (Review)	USA ($N = 15$), Denmark ($N = 4$), Sweden ($N = 3$), China ($N = 1$), India ($N = 1$), South Africa ($N = 1$)	Energy (N = 29), food (N = 6), mobility (N = 5)	Nudging (food, energy), information, feedback, social influences incl. goal setting, commitment, gamification (competition)	+/++ depending on the study	Individual

(Chile $n = 2$) (Carrico and Riemer, 2011; Dowd et al., 2012; Hall et al., 2013; Jacobsen et al., 2013; Largo-Wight and Wight, 2013; Cornelius et al., 2014; Hoicka et al., 2014; Matsui et al., 2014; Asensio and Delmas, 2015; Keall et al., 2015; Schultz et al., 2015; Morris et al., 2016; Nishida et al., 2016; Sintov et al., 2016; Staddon et al., 2016; Ro et al., 2017; Benka-Coker et al., 2018; Hammed et al., 2018; Wynes et al., 2018; Boso et al., 2019; Chiu et al., 2020; Malan et al., 2020; Jorgensen et al., 2021; Ruiz-Tagle and Schueftan, 2021).

Figures 2, 3 illustrate the 48 studies that were conducted in Europe (with Austria $n = 1$, Denmark $n = 5$, Finland $n = 1$, Germany $n = 1$, Italy $n = 2$, Netherlands $n = 5$, Portugal $n = 1$, Serbia $n = 1$, Spain $n = 2$, Sweden $n = 6$, Switzerland $n = 1$, United Kingdom $n = 21$) with one study only stating "Continental Europe" without further specifying the location (Bohdanowicz et al., 2011; Howell, 2011, 2012; Meloni et al., 2011; Quested et al., 2013; Brand et al., 2014; Reeves et al., 2014; Revell, 2014; Börner et al., 2015; Marchand et al., 2015; Mrkajic et al., 2015; Araña and León, 2016; Fisher and Irvine, 2016; Happer and Philo, 2016; West et al., 2016; Barata et al., 2017; Beitzen-Heineke et al., 2017; Damsø et al., 2017; Laakso, 2017; Aiken, 2018; Büchs et al., 2018; Howarth and Roberts, 2018; Kurz, 2018; Ornaghi et al., 2018; Wang and Boggio-Marzet, 2018; Wynes et al., 2018; Cellina et al., 2019; Casals et al., 2020).

One review only stated OECD countries (Dawkins et al., 2019), and two reviews did not specify the countries from which the intervention studies originated (Kelly et al., 2013; Iweka et al., 2019). In summary, most intervention studies were conducted in the USA and Europe, especially in the UK, but developing as well as transition countries could also be included in this review.

According to the 54 publications included in this review, 74 studies focused solely on energy, 12 on mobility, 10 on food, two on consumption, two on waste/recycling, and one on air pollution. Seven studies focused on more than just one emitting sector: one study targeted mobility and consumption in the tourism sector; one energy and water; one energy, water, and waste; two looked at energy, food, and mobility; and two targeted energy, food, mobility, and consumption. Consequently, PEB interventions for all emitting sectors of an individual could be identified, with the majority focusing on energy. Interestingly, no studies targeting air travel were found, which is in concordance with previous reviews (Wynes et al., 2018).

The level at which the intervention took place, is divided into (1) policy, (2) community, or (3) individual. Six publications, including one review, targeted the policy, eight studies focused on the community, and the majority, 33 publications, targeted the individual level only. Two reviews and five intervention studies described activities involving both the individual and community level. Table 2 summarizes the results including the targeted sector and level, intervention type, and effectiveness.

According to the evidence pyramid, randomized controlled trials (RCT) that randomly assign participants to a control or intervention group are the most reliable source of evidence (Murad et al., 2016). However, only 13 studies had an RCT design (see Table 2) although most studies provided a comparison with a control group or baseline (pre-intervention) measure.

Evidence-based effectiveness of single intervention types

Evidence from the literature endorsed Staddon et al. (2016) statement that interventions involving social influence, and/or structural measures seem to be particularly effective, and showed that feedback and policies also have the power to lead to significant emission reductions. Additionally, investing in behavior-changing PEB interventions can lead to a monetarily measurable return on investment: for example, Carrico and Riemer (2011) estimated that their interventions saved $15 (peer education) and $32 (feedback) in electricity costs for every dollar spent. However, the evidence-based effectiveness of the eight different intervention types mentioned in Section Pro-environmental behavior change interventions clearly shows that no intervention type on its own was very successful in

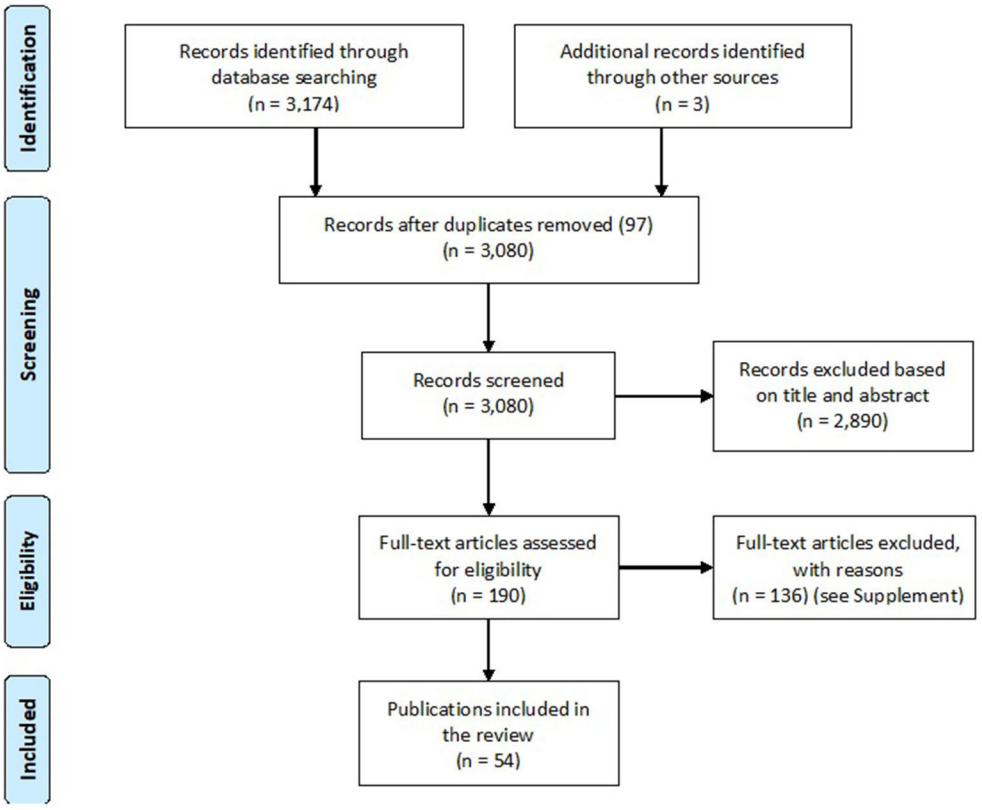

FIGURE 1
PRISMA flow chart of the conducted literature search [own representation based on Moher et al. (2009)].

promoting long-term behavior change. In summary, the studies demonstrated the following:

Providing information alone did not affect PEB, although it seemed to increase knowledge and change attitudes. However, this knowledge was not turned into PEB action, e.g., Showed that ambient learning displays had no significant influence on the conservation activities performed in the workplace (Hall et al., 2013; Börner et al., 2015; Morris et al., 2016; West et al., 2016; Barata et al., 2017; Büchs et al., 2018; Iweka et al., 2019). This is in line with existing literature by Stern and Abrahamse (Stern, 2000; Abrahamse, 2019). Interestingly, evidence showed that information alone can also backfire, i.e., lead to an increase in energy consumption (Carrico and Riemer, 2011; Staddon et al., 2016). Staddon et al. (2016) and Ornaghi et al. (2018) found that tailored information was more effective than general information. To increase this effect, information should be easy to understand and originate from a trusted source (Carrico and Riemer, 2011; Büchs et al., 2018).

Furthermore, Matsui et al. (2014) showed that providing feedback by using energy meters alone could not lead to a reduction in energy consumption, because the participants did not know how to reduce their consumption. Additionally, evidence showed that there is no difference in effectiveness between general feedback and feedback coming from a trusted source, e.g., peers (Carrico and Riemer, 2011).

According to Barata et al. (2017) commitments alone also do not affect PEB in the absence of other intervention types. Increased PEB could only be detected for commitment in combination with an educational intervention, but not without the other intervention.

Interestingly, evidence showed that nudging in terms of small changes to the environment had positive effects on its own regarding behavior change but only if the desired behavior and the needed skills, e.g., recycling, were already induced in individuals (Largo-Wight and Wight, 2013; Kurz, 2018).

Reeves et al. (2014) study even posed the question of whether social influence, e.g., in the form of community initiatives, can induce significant changes to their local area at all. Concerning incentives, Staddon et al. (2016) found that social rewards that are given publicly outperform other forms of incentives, e.g., money. Nevertheless, incentives (regardless of what kind and how much) alone do not promote behavior change—after an incentive is removed, individuals return to their old

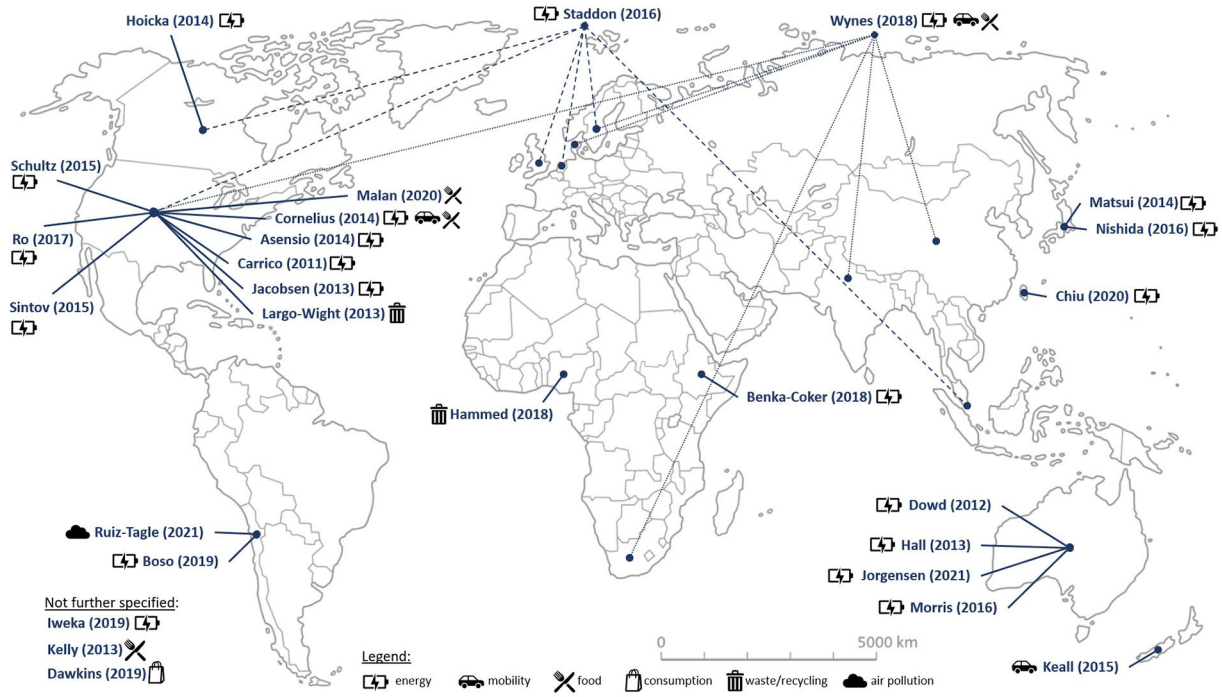

FIGURE 2
Worldmap as graphical summary of the results (except studies only conducted in Europe) regarding location and sector, which the intervention studies aimed at (own illustration).

habits (Asensio and Delmas, 2015; Iweka et al., 2019). However, being rewarded for PEB can further enhance the behavior, e.g., payments for not using the company's parking spaces (Wynes et al., 2018).

Interventions solely using gamification showed small positive effects during the intervention (Ro et al., 2017; Casals et al., 2020). Furthermore, Ro et al. (2017) indicated that individuals who changed their behavior during the gamification intervention were likely to still show this behavior at 1-year follow-up. However, engaging individuals to partake in games and maintain long-term involvement was a crucial issue in all gamification interventions. Usually, individuals' engagement declined over time, thereby limiting long-term behavior change (Cellina et al., 2019; Casals et al., 2020).

Regarding policies and compliance with them, the kind of policy is important: if a policy is mandatory, e.g., laws or a municipality only supplying "green energy" to all consumers, pro-environmental measures are automatically implemented without (or with only a limited need) for behavior change; if a policy is on an individual, voluntary basis without being enforced, individuals have the choice to comply with the policy or not. Bohdanowicz et al. (2011) reported that a hotel chain's sustainability policy was used to engage employees in PEB activities. However, the employees' engagement declined over time, leading to new efforts to re-engage employees. According to Hoicka et al. (2014), Marchand et al. (2015), and Howarth and Roberts (2018) policy programs suggested that voluntary energy audits for homeowners, who receive suggestions for retrofitting to reduce energy consumption, had no effect at all when they were not combined with economic incentives. If the energy audit was free of charge and technical improvements, e.g., retrofitting, were reimbursed, individuals were very interested in the implementation of energy-reducing techniques. Consequently, the resulting energy reduction was also high. A similar policy including the installation of a set of free-of-charge retrofitting measures, if necessary, led to a lower but still positive result. If no free-of-charge installations were made, and the costs of retrofitting actions had to be paid by homeowners, e.g., *via* a loan, no behavioral change or significant energy reduction could be measured. Consequently, the different results seemed to be based on economic incentives alone with apparently no effect of the policy itself to significantly reducing consumption (Morris et al., 2016).

Lastly, while structural measures can result in emission reductions, they are not always associated with behavior change. For example, one-time installations can reduce energy consumption significantly, like Schultz et al. (2015) LED bulbs, but do not change an individual's behavior (Revell, 2014; Keall et al., 2015). According to Brand et al. (2014) additional infrastructure, e.g., for cycling or walking, without any other

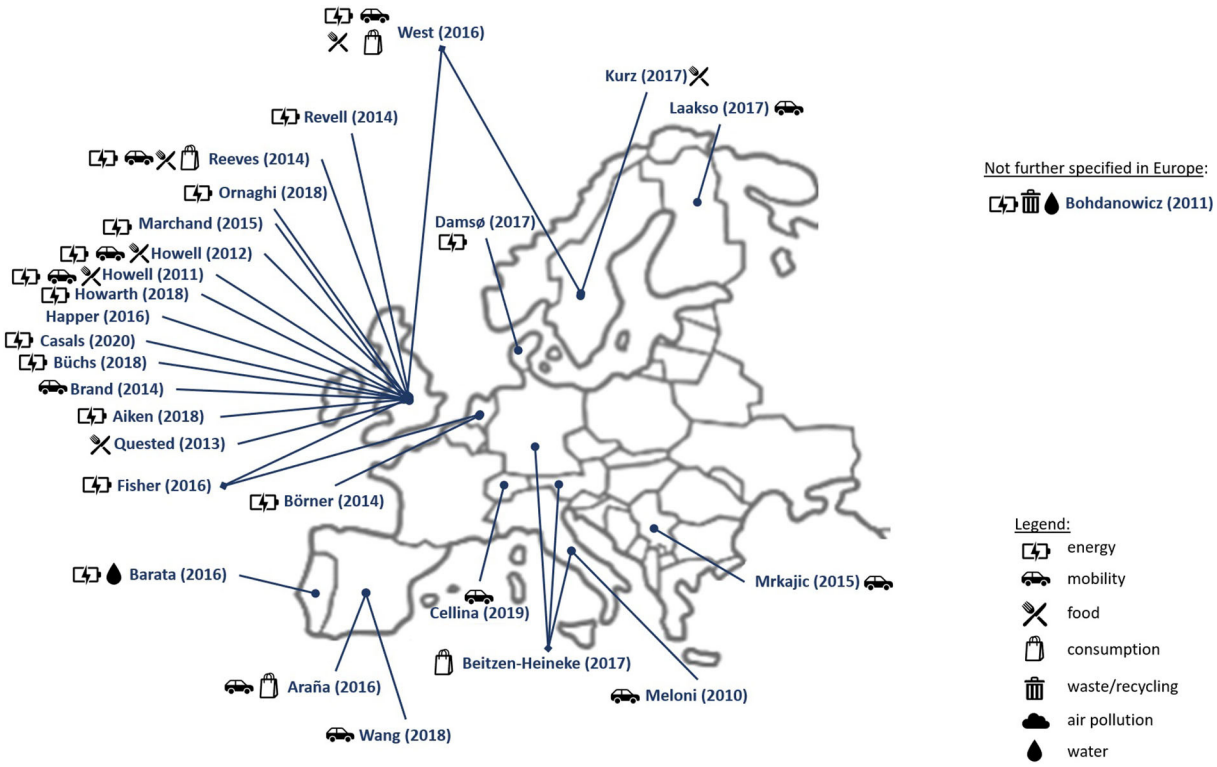

FIGURE 3
Graphical summary of the results regarding studies, which were only conducted in Europe, regarding location and sector, which the intervention studies aimed at (own illustration).

structural changes (roads closed or turned into one-way streets to make car use less convenient) did not change behavior toward switching from car use to environmentally-friendly alternatives. Instead, additional trips were made, mostly for recreational purposes, using the new infrastructure.

Consequently, the evidence shows that various intervention types should be combined instead of using only one single intervention type to change behavior. This is in concordance with findings from existing literature like Stern (Stern, 2000). For example, providing tailored information like health and risk information to persons with children or chronic diseases to raise awareness, and giving feedback on PEB actions afterward was shown to increase long-term commitment as well as PEB actions and significantly enhance behavior change (Hall et al., 2013; Asensio and Delmas, 2015; Morris et al., 2016; Staddon et al., 2016; Büchs et al., 2018; Iweka et al., 2019). The combinations of "feedback and educational/tailored information on how to change behavior" or "feedback and goal setting or commitment" (Iweka et al., 2019) are evidently able to promote behavior change (Matsui et al., 2014; Iweka et al., 2019). According to Wynes et al. (2018) most studies regarding energy used feedback (90% of all studies), and either paired it with information or gamification elements like rewards. Notably, only positive feedback should be given to avert negative responses from individuals (Carrico and Riemer, 2011; Staddon et al., 2016).

Very effective interventions use combinations of intervention types or make the sustainable option the default

Fifteen publications described very effective interventions (see Table 2) to change behavior and enhance PEB activities by (a) reducing energy consumption ($N = 13$), (b) encouraging recycling ($N = 2$), or (c) reducing car use ($N = 1$). They incorporated improved (infra-)structures, education, feedback, and enablement as well as making the sustainable option the default.

Damsø et al. described climate action plans with reduction targets, which were the basis for 51 mitigation initiatives using policies and structural measures. For example, the initiatives included improving the district's heating system, expanding wind power, or switching fuels in the municipalities' transport fleets (Damsø et al., 2017).

According to Hoicka et al. (2014) a government-initiated program encouraged individuals to invest in retrofitting and

energy-reducing measures. After a free-of-charge home visit, recommendations were given to individuals, who could then decide if they wanted to retrofit their home and what measures to install. After improving their homes, they could get financial rewards.

Laakso (2017) gave an example of making the sustainable option the default. In her intervention, households had to sell one of their cars, which could be either their only or second car. In exchange, they received free travel cards for local (bus) services. This disruption of everyday routines led to new mobility behavior, which was mostly maintained at follow-up with only one household buying a new car after the intervention. As a result, this one-time decision resulted in a remarkable reduction in car-induced emissions.

Largo-Wight and Wight improved the infrastructure to make PEB more convenient by adding indoor opportunities to recycle cans and bottles. This "nudge" increased the recycling rate compared to the default mode, which only provided bins outside the buildings. Consequently, recycling behavior became more convenient for individuals (Largo-Wight and Wight, 2013).

Wynes et al. stated that individuals adopt "green energy" from their suppliers nearly 10 times more often (69.1%) if it is provided as the default with the possibility to opt-out than do individuals (7.2%) who have to actively purchase the "green energy" option. Additionally, Wynes et al. found that feedback effectively helped to reduce energy consumption ("[…] average 133 $kgCO_2e$ reductions over 17 interventions in 11 studies […]" (Wynes et al., 2018, p. 12), and nudging as well as making the sustainable option the default effectively reduced the consumption of meat ["[…] average of 144 $kgCO_2e$ reductions over three interventions in one study […]" (Wynes et al., 2018, p. 12).

According to Staddon et al., 21 of 22 interventions used education or information whereby information that is easy to understand, contextualized, and from a trusted source was most effective. No reviewed intervention incorporated training. Five of the eight most effective studies used technological solutions for automation, i.e., automatically turning off appliances or adjusting (heating) settings. While these automations do shift the emission-saving behavior to technology, individuals can easily override or reset the settings if they are not aligned with their personal preferences. Overall, 7 of the 12 best performing studies included enablement, i.e., individuals were in control of devices and changing settings in combination with information on PEB. Furthermore, social influences appeared to enhance PEB (Staddon et al., 2016).

Dowd et al. (2012) described how fact sheets and group sessions enabled individuals to reduce their emissions and even inspired them to lobby their government to create a sustainable future. For example, "[…] emissions from beef showed the greatest decline (30%), followed by household energy (23%), spending (21%), transport (16%), and waste (16%)" (Dowd et al., 2012, p. 268).

Fisher and Irvine reviewed four small-group interventions incl. information material focusing on energy reductions. All groups increased their PEB compared to the control group with PEB maintained and even increased 3 years after the intervention had ended (Fisher and Irvine, 2016).

Howell described results from Carbon Rationing Action Groups, whose participants live with yearly carbon allowances that should not be exceeded. Group members encourage each other to reduce their carbon footprint and exchange experiences. Most groups incorporated financial penalties for exceeding the carbon target, or implemented trading "allowances" with other members who were significantly lower than the target (Howell, 2012).

A government-initiated program rewarding municipalities for every resident who signed up for paying a surcharge of 50% or 100% of their energy consumption to finance the expansion of "green energy" is described by Jacobsen et al. (2013) municipalities had to pledge to purchase a share of their services' energy from "green energy sources." If the number of residents who signed up exceeds a certain threshold, the municipality qualifies as "green" and receives free solar panels in proportion to the number of signed-up households. Especially the time around reaching the threshold is characterized by an increase in sign-ups, showing the social networking of individuals to reach a community goal, which led to a large number of "green energy" consumers.

Morris et al. (2016) described a program using home energy assessment incl. recommendations, for-free installations of measures, incentives, and quarterly energy efficiency information *via* electricity bills for island residents to reduce energy consumption. Additionally, reducing energy usage was a topic of discussion among islanders. As a result, after about 4 years the peak electricity demand had declined to below pre-intervention levels.

Educating individuals and training skills was described by Hammed et al. (2018) to reduce environmental pollution and increase recycling rates, a community-based intervention in Nigeria with community training was conducted to sensitize residents and develop as well as practice skills regarding waste management. None of the participants separated waste before the intervention whereas, after the intervention, 67.3% of the residents separated their waste. Additionally, harmful waste disposal practices were reduced, e.g., stream dumping decreased from 26.7 to 0.0%.

Giving feedback, setting goals, and engaging individuals *via* gamification led to the most significant reductions in energy consumption according to Iweka et al. (2019) review.

The Tokyo Cap-and-Trade Program to reduce emissions based on an emission target from non-residential buildings was described by Nishida et al. (2016) retrofitting measures focusing on heating/air conditioning and lighting, as well as social influences *via* organizational promoters led to high reductions. An additional factor for this significant sensitization and a

significant decrease in energy consumption was the energy crisis following the earthquake and Fukushima nuclear reactor incident in March 2011.

These successful interventions used combinations of information or education and training to enable individuals in changing behavior, goal setting, and improved infrastructures or setting the sustainable option as a default. Additionally, the encouragement using social influences, e.g., group discussions or role models, is highlighted as part of effective interventions. This is in line with the previous findings of Abrahamse (2019): block leaders and social modeling are effective in encouraging behavior change with modest to large effects.

Any intervention is better than none

According to the evidence, most interventions only showed small positive effects (see Table 2). As illustrated in Table 2, some interventions did not influence the targeted behavior at all. Nevertheless, small positive effects in non-targeted behavior could be achieved as described by Brand et al. (2014) although the infrastructural intervention was ineffective for its main outcome measure (CO_2 emission in the mobility sector), it effectively promoted walking for recreation, i.e., it improved health-related behavior.

In summary, except for one household participating in an energy trial (Matsui et al., 2014), there were no negative impacts (i.e., increasing negative impact on the environment) resulting from the interventions. In fact, this one outlier resulted from changing individual circumstances during the intervention and not from the intervention itself (Matsui et al., 2014). This is in concordance with Chiu et al. (2020) results from comparing their interventions with "no intervention" as they found that any intervention is better than none.

To highlight common denominators in the studies, the following sections cluster evidence according to the factors found including anecdotal examples.

Emotions, social, and cultural factors as evidence-based drivers and barriers to behavior change

Existing literature like Gifford (2011) name and discuss the psychological barriers to individual behavior change concerning PEB. For example, the impacts of individual behavior and the resulting GHG emissions on the environment are mostly distant or as Hargreaves found "invisible" and, thus, are perceived as "unrelated" to individuals' daily lives (Gifford, 2011; Hargreaves et al., 2013). Consequently, interventions need to raise awareness and make their objective relevant to participants to start the behavior change process. This means that there cannot be a "one size fits all" intervention approach. Instead, interventions need to be adaptable or customizable to individuals and their needs (Andersson et al., 2018). This includes the consideration of internal factors like emotions and external factors such as cultural factors, which is in line with the Model of PEB (Kollmuss and Agyeman, 2002; Araña and León, 2016; Benka-Coker et al., 2018).

For example, Benka-Coker et al. (2018) found that health and cost benefits alone are not motivating enough, if not "relevant," to promote PEB alternatives when it is inconvenient or not in line with traditions. Benka-Coker et al. (2018) conducted two interventions providing less GHG-emitting and air-polluting ethanol cookstoves to replace firewood to (a) refugees in different refugee camps and (b) low-income urban households. Depending on the origin of the refugees, the cook stove was either found to be suitable for all cooking needs or could not entirely replace firewood for traditional stoves, because it was not in line with customs, e.g., using large traditional pots for porridge, preparing traditional meals, or having ceremonial coffee. Interestingly, the more resources and alternatives participants had, the less successful the program was: in the refugee camps the ethanol stove was used as the primary stove, whereas the low-income urban participants practiced so-called "stove stacking," i.e., using two to five different kinds of stoves for different foods or purposes such as ceremonies.

Ruiz-Tagle and Schueftan showed that improving wood-burning technologies alone can lead to further problems because the user's behavior in operating the technology impacts the effectiveness of the improvement. For example, policies in Chile specified that only highly efficient "double combustion" stoves are to be available to the Chilean public. This led to decreased indoor but increased outdoor air pollution. Ruiz-Tagle and Schueftan used low-cost nudges in the form of information sign magnets to be installed above the stove's damper, aligning with the possible settings, to inform about the wood stove's emissions at the chosen setting. The damper setting regulates the airflow and, thus, the wood fuel combustion. Combustion and air quality improve with high air inflow, but the open flame might lead to higher firewood consumption and, consequently, increased wood-fuel expenses. Therefore, in Chilean households, the damper is mostly set to higher emitting settings with decreased air inflow. After field assistants provided information about the connection between damper settings and air quality including periodic check-in phone calls or visits, the individuals' behavior shifted to less polluting damper settings (Ruiz-Tagle and Schueftan, 2021).

However, Boso et al. (2019) demonstrated that awareness of a (health) problem, e.g., air quality, does not automatically engage individuals in behavior change. Instead, individual perceptions of the severity of the risk determine the willingness to participate in the intervention program.

On the other hand, Asensio and Delmas (2015) showed that persons with children provided with tailored, i.e., relevant, information about health issues like air pollution and asthma in children originating from energy consumption reduced their energy consumption by up to 19% compared to the controls. Other participants receiving the same information only achieved reductions of 8.2%. Happer and Philo highlighted that it is important to communicate risks (e.g., regarding health or property) in such a way that people can directly relate them to their experiences (Happer and Philo, 2016). This enhances the perceived relevancy in individuals.

Other examples of emotions and social factors as drivers and barriers are interventions regarding food, which is in line with existing literature like Stoll-Kleemann and Schmidt (2017). Behavior changes regarding food are not maintained long-term and interventions showed different levels of success depending on gender (Kelly et al., 2013). Besides monetary barriers to healthy eating, Kelly et al. (2013) concluded that nutritional interventions should include techniques to decrease emotional eating and increase social support. For example, men perceived certain behavior changes regarding diet as risking social ramifications and, thus, did not want to engage in such changes. According to the nudging intervention of Kurz, the sales of vegetarian dishes increased, but with varying numbers across different kinds of dishes (Kurz, 2018). Thus, vegetarian patties were more in-demand than stews, which could be related to their appearance resembling typical meat-related dishes like burgers (Kurz, 2018). Other interventions even showed backfiring effects with increased meat consumption due to the intervention: the authors assume that they unconsciously stimulated participants by repeatedly directing their attention to meat-related images and texts (Klöckner and Ofstad, 2017; Wynes et al., 2018).

Emotions also play a role in consumption, e.g., travel decisions. Araña and León found that CO_2 emissions (measured as tons per person) increased when individuals were under time pressure or sad while booking a tourist package. Carbon taxes, CO_2 labeling, and a high level of empathy for future generations led to decreasing CO_2 emissions with high taxes (>10%) and empathy being statistically significant and, thus, most efficient. Consequently, interventions may unintentionally discourage PEB activities, if they cause sadness in people (Araña and León, 2016).

Additionally, Mrkajic et al. (2015) promoted emission-reduced mobility, i.e., cycling, by providing a bicycle parking area that students perceived as secure. Previous bicycle parking areas were perceived as unsafe and, thus, presented a barrier to changing mobility behavior.

Marchand et al. (2015, p. 104) conclude that individual choices and adapting interventions to align with an individual's existing routines, could "[…] prevent rejection of potentially beneficial measures [...]." For example, the convenience of recycling opportunities influences the impact of encouraging recycling, and wall insulation measures affect the appearance and/or size of a house (Carrico and Riemer, 2011; Marchand et al., 2015). Revell stated that installed retrofitting measures might even be removed by individuals who perceive them as inconvenient or ineffective (Revell, 2014).

In summary, when individuals have alternatives, they will use the most convenient option, e.g., motorized travel (see Brand et al., 2014), stick to their former behavior, e.g., cooking behaviors (see Benka-Coker et al., 2018), or use the option that makes them feel better (see Araña and León, 2016). Especially traditions or socio-cultural expectations are relevant for certain sectors like food and mobility. For example, this is due to traditional eating habits, a greater spatial spread of family and work environments, or the greater array of opportunities for low-cost travel by car and plane (Benka-Coker et al., 2018; Büchs et al., 2018). Additionally, external barriers (infrastructural and social) and "[…] concerns about impracticality, inconvenience, unreliability and higher costs […]" (Büchs et al., 2018, p. 290) reduce the willingness to change behavior.

Enabling and motivating behavior change based on evidence

To engage and motivate individuals in behavior change, PEB-related goals should be both achievable and challenging. "Achievable" means that individuals need to be able to change, i.e., have the knowledge of alternatives and means to alter behavior as demonstrated by Matsui et al. (2014). Fisher and Irvine found that the simpler the behavior change advice the more reductions can be achieved (Fisher and Irvine, 2016). For the energy sector, Asensio and Delmas found that information on appliance-level electricity consumption was valued as most useful, surprising individuals by reflecting on how much or little appliances consumed energy, or were being used (Asensio and Delmas, 2015). This led to "[…] primarily […] plug load and lighting behavioral changes" (Asensio and Delmas, 2015, p. 4) with "[…] the most commonly reported behavioral changes […] [being] turning off unused lights, unplugging electronics, and charging devices when not in use" (Asensio and Delmas, 2015, p. 5). Additionally, Jorgensen et al. (2021) found that after giving participants the information about reducing energy consumption during peak demand periods, the 8-h notification of an upcoming energy peak demand period was more effective than 24-h notifications with a "2-h before peak demand period"-reminder. This result was unexpected due to the greater temporal distance and the authors speculated that the 24+2 scenario "[…] provoked psychological reactance" and, therefore, was experienced negatively by the participants (Jorgensen et al., 2021, p. 12).

According to Staddon et al. (2016) review, 7 of the 12 most effective studies used enablement (e.g., direct support,

techniques, tools, and aids) to provide individuals with the necessary means to change their behavior—in addition to other intervention types. Quested et al. (2013) described how habitual elements of intervention activities using repetition, and linking related issues raised awareness and led to measurable positive effects. Furthermore, education in the form of active training showed positive effects on behavior change. For example, Hammed et al. (2018) showed this to be true for workshops regarding recycling management. Additionally, Wang and Boggio-Marzet (2018) demonstrated that a one-time training course regarding eco-driving immediately affected individuals' driving behaviors, e.g., leading to altered average/maximum speed, less aggressive acceleration, and measurable reductions in fuel consumption. However, the intervention did not include a follow-up and, thus, limits the findings to short-term behavior change only (Wang and Boggio-Marzet, 2018).

According to Reeves et al. (2014) and Cellina et al. (2019) long-term commitment to PEB activities, a prerequisite for behavior change, is problematic. Cellina et al. (2019) used commitments and social support to motivate long-term behavior change. Interestingly, "private commitments lead to higher energy conservation than public commitments" (Iweka et al., 2019, p. 5). In general, social influence and (peer) competitions seem to be very motivating in promoting PEB (Sintov et al., 2016; Staddon et al., 2016; Cellina et al., 2019). However, social influence needs persons to act as role models, e.g., "block leaders." This can be achieved by peers, e.g., in Aiken's study neighbors, who share interests in certain sustainability options being brought together to share their thoughts or experiences, and thereby support and reinforce each other's behavior changes (Aiken, 2018). However, as Reeves et al. (2014) stated "[…] social movement framed around sustainability or climate change is likely to attract only limited levels of support and active participation [...]" (Reeves et al., 2014, p. 127). Long-term social influences, e.g., in the form of grassroots initiatives dissolve when no willing group or block leaders can be found.

Low-cost behaviors and transition phases constitute good starting points for PEB interventions

According to the findings of Büchs et al. "[…] participants were mostly willing to consider changes which would either bring them a personal benefit (e.g., getting fitter by walking more) or which would not affect their lifestyles too much" (Büchs et al., 2018, p. 290) with varying degrees of willingness "[…] depending on what aspect of their lifestyle [the change] impacts" according to West et al. (2019, p. 404). Therefore, behavior change is mostly in favor of low-cost behavior, which is in line with Diekmann and Preisendörfer (2003) theory of low- and high-cost situations. For example, Barata et al. (2017) showed that students could more easily be motivated to adopt water-saving behavior than energy-saving behavior. Also, the behavior changes to switching off appliances when not in use reported by Cornelius et al. (2014) and Asensio and Delmas (2015) studies are easy to implement and, thus, low-cost behaviors.

Additionally, Hall et al. (2013), Quested et al. (2013), and Laakso (2017) state that the best opportunity to implement behavior change is during transition phases like moving to new accommodation, changing jobs, having a child, or joining/leaving the labor force. Such transitions already disrupt behavior patterns, making a change toward PEB and implementing new routines easier.

For example, Malan et al. (2020) found that a "Foodprint seminar" regarding food systems and sustainability aspects as a university course shifted students' dietary intake with a tendency to decrease their food-related carbon footprint, especially among frequent ruminant meat consumers. The seminar topics helped to motivate behavior change and increase food literacy by highlighting impacts on social justice and environmental sustainability. Since college and university are natural transition periods, the seminar's timing might also contribute to the described behavior change.

The role of governments and politics

According to Dowd et al. (2012), Happer and Philo (2016), Damsø et al. (2017), and Dawkins et al. (2019), framework conditions set by national/local government influence how problems, e.g., GHG reductions, are tackled—especially when it comes to long-term effects. Governments can target and engage different sectors and groups. For example, if regulations specify that only the sustainable option, e.g., renewable energy, is to be used as a default, every individual, business, and sector will automatically consume more sustainable energy—in a few cases even without the need for active behavior change of individuals. Governments can also take a leading role, prioritize interventions, and provide funding, which is a frequently mentioned barrier regarding interventions, their resources (e.g., staff, and technology), and their scalability (Ruiz-Tagle and Schueftan, 2021).

For example, the government in Chile banned the use of wood-burning stoves in areas with high air pollution during emergency periods. Boso et al. (2019) described a governmental program to subsidize all costs (incl. a new stove, installation, and removal of the old stove) for replacing wood-burning stoves to support the transition toward more sustainable stove types.

However, this policy shifted indoor air pollution to outdoor air pollution because of the stove users' behavior, thereby calling for subsequent behavior change interventions (Ruiz-Tagle and Schueftan, 2021).

Another example is the Tokyo Cap-and-Trade Program to reduce emissions from non-residential buildings as described by Nishida et al. (2016) which led to high reductions. Policies to reduce energy consumption in non-residential buildings (e.g., offices, communication businesses, and data centers) can lead to significant emission reductions.

The reviewed studies also provide recommendations for policy-makers. Wang and Boggio-Marzet (2018) recommend that local policymakers and transport planners implement a so-called "green wave." Coordinating traffic lights on routes with intensive traffic flows ensures constant speed and, thus, eco-driving with reduced ac-/decelerations. Additionally, mandatory eco-driving education should be integrated into driving license courses.

Furthermore, problematic issues can be addressed by using evidence. Since driving cars is the most dominant transport mode as described by Meloni et al. (2011) and Keall et al. (2015) policy-makers could subsidize more (infra)structural measures to encourage active travel modes, e.g., cycling.

Beitzen-Heineke et al. (2017) described the alternative retail concept of zero packaging grocery stores to reduce packaging waste, potential food waste due to packaging guidelines, or marketing (e.g., excessively large packaging). Individuals supporting the growing number of such stores despite the inconvenience resulting from a more time-consuming shopping experience, limited product range, and the need to clean and bring their own containers could provide a lobby for political packaging-related issues.

Consequently, individuals can influence their local government by lobbying and using their votes (Dowd et al., 2012; Happer and Philo, 2016; Damsø et al., 2017; Dawkins et al., 2019). However, one barrier to lobbying might be individuals' distrust of policy-makers as described by Happer and Philo (Happer and Philo, 2016).

Discussion

All but 10 of the reviewed intervention studies took place in so-called developed, high-emitting countries, which need to reduce emissions most urgently. However, meeting social needs and emission goals, while enabling economic growth in developing and transition countries should also be brought into the focus of sustainability research.

In line with the findings from Wynes et al. (2018), this review identified more interventions targeting the energy sector than mobility, food, consumption, and waste/recycling combined. Most studies focused on individuals and changing their behavior.

Limitations regarding the search strategy

The presented search strategy defined exemplary emission sectors of interventions by search words, but should not be limited to specific sectors. Therefore, publications concerning other emission sectors that appeared in the search were also included in this review. Since the search words made the search and its results reproducible, this approach should not undermine the systematic character of this review. Despite this broad approach, this review may be influenced by publication bias, thereby limiting its overall validity to the results found.

Study designs and intervention types

This review's results are based on findings from the literature concerning behavior change interventions toward PEB and, consequently, the quality of these intervention studies. The study designs allow for biases compromising the quality of the results. For example, self-reported outcomes in questionnaires are vulnerable to biases such as "social desirability," "recall," and "reporting" (Meloni et al., 2011; Dowd et al., 2012; Revell, 2014; Sintov et al., 2016; Staddon et al., 2016; Ro et al., 2017; Iweka et al., 2019). Additionally, an individual's behavior might change simply by taking part in an intervention study (Hawthorne effect) (Iweka et al., 2019; Ruiz-Tagle and Schueftan, 2021). Furthermore, RCTs are not common in research regarding PEB-promoting interventions but would yield the most robust evidence. Interestingly, studies with an RCT design showed no or only small positive effects with only one successful outlier, namely a subgroup of people with children, who responded to health messages with higher reductions in energy use (Asensio and Delmas, 2015). This could suggest that behavior change toward PEB is not possible in all individuals.

The lack of success in the majority of interventions is often explained by a recruiting bias in voluntary sustainability interventions or, as Howell called it, "preaching to the converted" (Howell, 2011, p. 184). This means that individuals participating in the interventions cannot achieve high reductions or effects, because they have already adjusted their lifestyle toward more sustainability. Cellina et al. (2019) stated that the lack of an intervention effect could be due to the fact that the study participants in Zurich already showed more PEB than the average population. Büchs et al. (2018) also reported a PEB response bias and thus limited possible effects of the intervention. Like most researchers, Jacobsen et al. (2013) found that the majority of their participants had a higher level of education than the average population. Concerning her successful intervention, Laakso declared that "Many of the participants had considered giving up ownership of their cars already before the experiment, and seeing the announcement in a local newspaper was the incentive they needed to make

the final decision" (Laakso, 2017, p. 138). Bohdanowicz also stated that the respondents of the survey are most likely more interested in environmental issues than non-responders (Bohdanowicz et al., 2011).

Since most studies are characterized by small sample sizes, as well as short interventions and, if applicable, follow-up periods, the effects, statistical results, and generalizability can be negatively influenced (Sintov et al., 2016; Iweka et al., 2019). For example, Barata et al. (2017) based their results on a 1-month intervention period aimed at teenagers, which are only a part of a given household, and a control sample for saving readings of $N = 7$. Chiu et al. (2020) had a study period of 4 weeks with 3 weeks of intervention and, thus, without the possibility to measure long-term behavior change. Cornelius et al. (2014) and Sintov et al. (2016) studies lasted 7 weeks without follow-up, Largo-Wight and Wight analyzed 8 weeks, with only a 4-week-long intervention, and Wang et al. conducted a 1-month-long study (Largo-Wight and Wight, 2013; Wang and Boggio-Marzet, 2018). The study by Meloni et al. (2011) was the shortest at 2 weeks, including a 1-week-long intervention.

Especially, interventions regarding the food sector would benefit from longer intervention durations and follow-up periods. Wynes et al.'s findings that "[…] the majority of studies described measurements for a period of weeks only, making it difficult to assess the persistence of any interventions" (Wynes et al., 2018, p. 15) are in concordance with the findings of this review. Especially, interventions in canteens, which mostly target one meal per work day and, consequently, five meals a week, need long intervention durations to create a robust effect. Only Malan et al. (2020) had a longer study period of one academic term, i.e., 10 weeks.

For food interventions aiming at increasing the sale of vegetarian dishes, e.g., in canteens, Kurz suggested examining a dish's food components in detail, because vegetarian food can cause higher GHG emissions than a meat dish. For example, this is true for cheese when used to substitute for meat, if the alternative is a dish with more climate-friendly meats such as poultry. Therefore, food interventions should consider measuring the sale of more vegan alternatives or dishes with fewer dairy products. Consequently, the results from sale-based interventions should be treated with caution (Kurz, 2018).

Furthermore, the setting and timing of interventions could bias results. For example, Carrico and Riemer collected baseline energy consumption data in summer (May to August), but the intervention and its data collection took place in fall/winter (September to December) when energy consumption naturally rises due to the use of heating (Carrico and Riemer, 2011). Meloni et al. (2011) conducted their first survey week in summer, while the intervention week was in autumn, which could also lead to measurement biases based on changed weather conditions. Cellina et al. (2019) stated that their mobility intervention might have been unsuccessful because it was conducted during winter, which—due to weather conditions—is less bike- and slow-mobility-friendly. Jorgensen et al. (2021) also stated that their measurements might be biased because students might just have left their residence during energy peak demand periods to use energy elsewhere on the campus.

Lasting reductions due to social influence, i.e., group interventions, are in line with Abrahamse et al. (2005), Abrahamse (2019) findings. According to Hall et al. (2013) face-to-face group interventions resulted in more actions performed as PEB changes than in online groups. However, Fisher and Irvine found that smaller groups will most likely consist of individuals with existing PEB intentions and, thus, limit activities on a wider societal scale (Fisher and Irvine, 2016).

Additionally, social influence *via* comparative feedback, e.g., using information about peers as a benchmark, could lead to a certain sense of competition and increased PEB, but it can also lead to non-compliance when individuals justify their behavior by using this benchmark. For example, if peers show less PEB it might serve as a demotivation to engage in further PEB activities since one's outcome is already better than the results of others. Additionally, distinctiveness (e.g., income, lifestyle, household characteristics) could be used as a justification for not engaging in further PEB activities or even increasing consumption (Wynes et al., 2018; Iweka et al., 2019).

Behavior change models and intervention measurements

While some interventions did not consider Behavior Change Models, others most often mentioned the Theory of Planned Behavior (TPB), and the Transtheoretical Model (TTM). For example, Cellina et al. (2019) designed their intervention based on the TTM with different intervention types for each behavior change stage. The evidence showed that behavior change is influenced by multiple factors, e.g., emotions, and social and cultural factors, which supports Kollmuss and Agyeman's model of pro-environmental behavior (Kollmuss and Agyeman, 2002).

In concordance with Happer and Philo, the lack of knowledge and understanding regarding climate change and possible (individual) solutions were consistent across studies, which was measurably increased by interventions (Happer and Philo, 2016). This also supports the model of Kollmuss and Agyeman, who base environmental consciousness on knowledge, which influences emotions as well as values and attitudes (Kollmuss and Agyeman, 2002).

Another aspect supporting the model of pro-environmental behavior is that, according to the evidence, only combinations of interventions were really successful. Since the model includes barriers to every aspect of behavior, behavior change is more likely when various barriers are targeted and removed. A combination of interventions automatically addresses different factors, e.g., information targets knowledge,

increasing awareness, and environmental consciousness while gamification, such as challenges, motivates individuals to engage in PEB.

The success of interventions is measured with different metrics, e.g., kWh, or $kgCO_2$, and *via* various techniques, e.g., smart meter readings, GPS travel information, or electricity bills. Especially if interventions during different seasons are included, a control for changes in weather conditions would be advisable. However, since not all studies included such data, the comparability of findings is subsequently reduced.

Another aspect is that changes in emissions could originate from other sources, e.g., national changes/activities, which are outside of the intervention's scope. Additionally, with changing societies and advances in technology, e.g., more efficient appliances, the impact of an intervention is likely to change over time. All these aspects should be considered when assessing and comparing an intervention's effectiveness.

The possibility for behavioral change

Although structural measures and automation are successful in reducing emissions, the question remains whether such measures can be called "PEB." Technological solutions mostly do not aim to promote behavior changes. In fact, most one-time changes like sustainable default settings or switching to the "green" energy tariff can persist without maintenance and, thus, without the need for any behavior change, thereby preventing the risk of relapses or rebounds (Morris et al., 2016). However, Staddon et al. (2016) state that technological changes can create a new environment in which behavior change can be induced. For example, individuals who had retrofitting measures installed can serve as role models and examples to their social network when showing off the changes (Marchand et al., 2015).

However, large-scale behavior change toward PEB currently seems to be an unsolved challenge. Revell stated that the result of behavior change regarding energy and water savings behavior after home energy audit visits was negligible (Revell, 2014). According to Happer and Philo, the "[. . .] majority had not made changes to their behavior. [. . .]" (Happer and Philo, 2016, p. 145) which suggests that behavior change is only possible in individuals who were willing to change prior to the intervention.

Evidence-based recommendations for interventions on enhancing PEB

While deriving recommendations from evidence is considered best practice in most research areas, generalizability depends on the type, amount, quality, and consistency of the evidence. The most robust recommendations are based on multiple, independent studies of high quality. To indicate how robust a recommendation is, the terms "limited," "medium," or "robust" are used in the following.

The following recommendations can be derived from the evidence on how interventions for enhancing PEB should be designed and implemented:

First, make the sustainable option the default, or more convenient. Robust evidence shows that the fewer alternatives there are, the higher the level of compliance (Largo-Wight and Wight, 2013; Hoicka et al., 2014; Staddon et al., 2016; Damsø et al., 2017; Laakso, 2017).

Second, concentrate on high-impact behavior. Wynes et al. (2018) quantified how much emissions were reduced by interventions focused on individuals' behavior. As a result, the impact of behavior change can be quantified whereby interventions that focus on reducing car usage and the resulting emissions seemed to have the highest impact. Reducing household energy consumption had the second-highest impact followed by emission reductions regarding food. The robustness of this recommendation can be considered "medium" based on multiple data presented in reviews (Bundesministerium für Umwelt, 2018).

Third, interventions conducted in developing and transition countries prove that without previous sensitization even relatively low-effort interventions like education and training, e.g., on recycling, can have a high impact on behavior change toward PEB activities and environmental issues involving water, land, and air pollution. Since the publication basis for developing and transition countries is very limited, this finding should also be considered "limited" (Hammed et al., 2018; Ruiz-Tagle and Schueftan, 2021).

Fourth, as the most successful interventions prove and, thus, give robust evidence, use a combination of intervention types, e.g., tailored information to raise awareness and trigger engagement, education, and training to enable and self-empower individuals to change their behavior, and continuous feedback to enhance long-term commitment. Consequently, PEB change goals need to be achievable and challenging to engage and motivate individuals.

Fifth, disrupt routines or use transition phases to successfully change behavior (Hall et al., 2013; Quested et al., 2013; Laakso, 2017). Although only a limited number of interventions used this method and, thus, this recommendation would only be considered "medium," further research and intervention planning should consider disrupting routines as it is known to increase possibilities for behavior change (Stieß and Rubik, 2015).

Conclusions

This systematic literature review assessed the evidence-based effectiveness of 54 publications regarding behavior change interventions for enhancing PEB in individuals. The review identified very successful interventions to increase PEB, which were described in the results section. To the best of our knowledge, this paper is the first to

conduct a review regarding the contents of behavior change interventions regardless of the emitting sector or targeted level and, thus, its findings advance the body of knowledge to plan and implement behavioral intervention studies.

In summary, the various interventions and intervention types to promote PEB differ in their effectiveness, leading to several evidence-based insights. No single intervention type by itself was successful in long-term behavior change and, according to the evidence, most interventions showed only small positive effects. Only 15 publications described very successful interventions. However, every intervention is better than none. This proves that effective interventions to increase PEB exist, but a combination of intervention types is the key to success. To change behavior, PEB goals should be both achievable and challenging to engage and motivate individuals. Additionally, emotions and social and cultural factors are both drivers and barriers to behavior change, in favor of the model of pro-environmental behavior designed by Kollmuss and Agyeman (Kollmuss and Agyeman, 2002). Interventions are most successful when the sustainable option is the default/new "normal," or more convenient. Furthermore, the best opportunity to implement behavior change is during transition phases or after disrupting routines. For example, some authors conclude that interventions in college or university settings are promising. Moreover, interventions should concentrate on high-impact behavior, i.e., reducing (1) air travel and car usage, (2) household energy consumption, and (3) emissions regarding food. Interestingly, even relatively low-effort interventions in developing and transition countries can successfully change behavior toward PEB and reduce pollution of water, land, and air. Consequently, PEB interventions should include such countries more. Therefore, this paper contributes more generally to the growing literature on the broader topic of "PEB interventions" and in helping to develop very successful evidence-based interventions.

Future interventions should include follow-ups to monitor whether a changed behavior could be integrated as a habit in an individual's way of life and, thus, is maintained long after the intervention ended. Moreover, new interventions should have longer intervention or study durations as well as randomized controlled study designs. Additionally, research should focus on high-/low-impact as well as high-/low-cost behavior to develop interventions, which are more focused on high-impact but low-cost behavior changes, or avoid low-impact but high-cost behavior changes.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

HR and SS-K: conceptualization and methodology and conducting the review. HR and SN: writing—original draft preparation. HR, SN, and SS-K: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.901927/full#supplementary-material

SUPPLEMENTARY DATA SHEET 1
Database searches.

SUPPLEMENTARY DATA SHEET 2
Excluded publications.

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Thermal demands and its interactions with environmental factors account for national-level variation in aggression

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Literature shows that psychological phenomena, including values (e.g., individualism vs. collectivism), personality, and behaviors (e.g., prosocial and aggressive behavior), are geographically clustered. The effects of temperature on interpersonal and intergroup aggression have been studied by many social psychologists. To date the interactions between temperature and other geographical factors have not been addressed. This study is aiming to examine the effects of thermal demands and the moderating effects of natural geographical factors on aggressive behavior at national level. Data for 156 societies was obtained from publicly available databases. Consistent with the life-history theory, results of this study showed that aggressive behavior has a positive relationship with heat demands, and a negative relationship with cold demands. Aggressive behavior is also positively correlated with sunlight and altitude, and negatively correlated with coastline vicinity. Forest, coastline vicinity, and rainfall moderated the effect of thermal demands on aggressive behavior. In societies with more forests, with more rainfall, and closer to coastline, the negative effects of cold demands on aggressive behavior are stronger.

KEYWORDS

aggressive behavior, moderation effect, natural geographical factors, temperature, thermal demands

Introduction

Surrounding air temperature or ambient temperature is one of the basic living conditions that influence human social behavior. In recent years the effects of temperature on aggressive behavior have been revealed by many researches (Van Lange et al., 2017; Berman et al., 2020; Potgieter et al., 2022). Aggressive behavior refers to actions that cause physical or psychological harm to others. Broadly speaking, it includes hostile actions causing harm to another person or group, such as bullying, interpersonal conflicts, robbery, political violence, war, and riot (Van Lange et al., 2017). Aggressive behavior

sometimes can subjectively be used as a protective mechanism against physical and psychological threats. However, it often objectively impair healthy interpersonal relationships, bring harm and even long-lasting loss (Van Lange et al., 2017). Impulsive personality trait and negative emotionality have been considered as predictors of aggressive behavior (Jones et al., 2011), while good self control abilities and emotion regulation skills can reduce the occurrence of aggression (Roberton et al., 2012). Researchers found that deviant temperature can induce negative emotions, which lead to increased aggression (Van Lange et al., 2017). For example, Rotton and Cohn (2003) found a positive association between temperature and state-level malicious behaviors in the United States. Mares and Moffett (2019) suggested that global warming may enhance aggressive behavior.

Psychological phenomena are spatially clustered (Rentfrow et al., 2013; Steg et al., 2018). Geographical factors (e.g., temperature, rainfall, soil, pathogen prevalence) were found to be associated significantly with many aspects of human psychology, including thoughts, emotions, and behaviors (Hsiang et al., 2013; Rentfrow, 2020). Plenty of studies have found geographical differences in psychological phenomena across nations/regions, such as personality (e.g., Jokela et al., 2015; Stavrova, 2015), cultural values (Van de Vliert, 2013a,b), subjective well-being (e.g., Jokela et al., 2015). These psychological phenomena are closely related to aggressive behavior. To date few studies have examined how environmental factors jointly affect aggressive behavior. This study is aiming to examine the effects of thermal demands and other natural geographical factors as well as their interactions on aggressive behavior at national level. This may throw new light on the understanding of human social psychology (e.g., Van de Vliert and Conway, 2019).

Cold and heat demands

Human social behaviors can be greatly affected by temperature and other environmental factors, such as relative humidity and the amount of sunlight (Tiihonen et al., 2017). All warm-blooded animals are required to maintain constant levels of body temperature. In humans the relationship between ambient temperature and metabolic rate or body heat production tend to be U-shaped (Van de Vliert, 2013a). Specifically, when ambient temperature is appropriately 22°C, the metabolic rate of human body is minimal. When ambient temperature is lower than this reference point, metabolism increases to produce enough heat (e.g., by shivering) in order to maintain normal temperature (about 37°C) for the human body to survive. When ambient temperature is higher than 22°C, the metabolism also increases to support active cooling (e.g., sweating, panting). And human groups have adapted their behaviors to thermal climate to meet their basic survival needs. Accordingly, the ways people interact with the physical and social environment can be shaped by demanding thermal climate (Van de Vliert, 2013a).

Average temperature has been used as a national level predictor of important psycho-social outcomes (e.g., subjective well-being, freedom). But average temperature is a flawed proxy of demanding thermal climate (Fischer and Van de Vliert, 2011; Van de Vliert, 2013a,b). The main reason is that hotter-than-temperate and colder-than-temperate temperature posed different challenges for humans and consequently showed different effects on human psychological dispositions and behavior (Murray, 2013; Van de Vliert, 2013b; Stevens et al., 2021). For humans 22°C is the most comfortable temperature under which the needs for nutrition and health can be more easily met. Large deviation from 22°C represents less availability of living resources (e.g., animals, plants). Therefore, cross-cultural studies should use variation from the comfortable temperature (both below and above 22°C) instead of average temperature as national level predictor. Van de Vliert (2013b) put forwards the concept of climate demands (i.e., thermal demands) and operationalized it as the sum of the absolute deviations from 22°C across major cities of each country. Considering that coldness and heat may have differential effects on human behaviors, indices of cold demands (to represent survival challenges posed hotter-than-temperate climate) and heat demands (to represent survival challenges posed colder-than-temperate climate) were further proposed (Van de Vliert, 2013b).

Empirical studies on temperature and aggressive behavior

Abundant research has found the negative impact of high temperature on social behavior and mental health (Berman et al., 2020; Suh et al., 2021). City-center riots, for example, appear to be more common during hot summers and less frequent in cold winters. Cities with higher mean temperature show higher violent crime rates compared with cities with cooler average temperature (Anderson and Anderson, 1996; Anderson et al., 1997). A global level meta-analysis found that high temperature was a major contributor of interpersonal violence and group conflicts (Hsiang et al., 2013). Using the average regional temperature in the United States between 1950 and 1999 as a predictor, Rotton and Cohn (2003) found that annual average temperature was positively associated with physical assault, property crime, and violent crimes. Countries close to the equator experience significantly more aggression and violence than countries far from the equator (Van Lange et al., 2017).

But not all studies found that negative outcomes are caused by hot temperature (Stevens et al., 2021). Russia, Afghanistan, and South Africa are not hot countries, but they all have high domestic violent prime rates (Potgieter et al., 2022). In a global level investigation in 2020,[1] homicide rate per 100,000 people in South Africa was 33.97, in Russia was 10.82. Using average annual temperature as predictors, Prudkov and Rodina (2019) found that

1 http://worldpopulationreview.com/

decreased temperature led to increased violent crime in Russia. They further found that in Russia there was more violence in winter and spring months compared with that in autumn months. Using another national level dataset, Iyigun et al. (2017) found that during 1,400 to 1900 low temperature led to an increase in conflict in Europe, North Africa, and the Middle East. The reason is that coldness hampered agricultural production and caused serious social problems such as food shortages and robberies.

Inconsistent results regarding the effects of temperature on aggressive behavior suggest the necessity to take other natural environmental factors into consideration. For example, Sudan and Singapore are hot countries with a yearly average temperature near 28°C, their difference in aggression (Sudan = 1.71, Singapore = −0.38) suggest the influence of natural environmental (e.g., rainfall, forest) and social-economical factor (Van de Vliert and Daan, 2017). These factors and temperature may jointly influence aggression (Hsiang et al., 2013; Abel et al., 2019; Potgieter et al., 2022).

Environmental factors and aggression

Various aspects of geographic environment can affect human psychological processes and behaviors (Rentfrow et al., 2013). Psychologists have observed personality similarities among people living in the same geographic spaces. This is because physical environments shaped human psychology and behavior. Based on previous literature, we examined the effects of sunlight, forest resource, coastline vicinity, rainfall, as well as altitude on aggressive behavior, and the moderating roles of these environmental variables in the relationship between thermal demands and aggressiveness (Hsiang et al., 2013; Sanciangco et al., 2022). All economic and cultural factors were excluded from this study, because they can be considered as the outcomes of natural environments (Henseler and Schumacher, 2019; Van de Vliert and Conway, 2019).

Sunlight affects people's psychology and behavior (Esteky et al., 2020). Lambert et al. (2002) found that the human brain production of serotonin was the least in winter, a season short of sunlight. As luminosity increased, serotonin production elevated rapidly. aan het Rot et al. (2008) found that increased natural light intensity led to more positive social interactions and fewer disputes. Therefore, this study hypothesized that societies with more sunlight have fewer aggressive behaviors. But the relationship between sunlight and social behavior may not be linear. Bright light can enhance positive behavior, but can also amplify negative behavior. For example, bright light leads chronically interdependent self-construal individuals to engage in positive behaviors (i.e., more prosocial behaviors), but leads chronically independent self-construal individuals to engage in negative (i.e., less prosocial) behaviors (Esteky et al., 2020).

Forests are familiar environment in human evolutionary history. And human physiological functioning is adapted to this environment (Ikei et al., 2017; Sanciangco et al., 2022). Forests make people more relaxed and comfortable, and help them alleviate negative emotions such as anger-hostility, tension-anxiety, depression, and fatigue. Walking in a forest leads to decreased heart rate and heart rate variability, and lower blood pressure and pulse rate (Song et al., 2019), blood pressure and stress level (Ikei et al., 2017). This suggests that forest environment can reduce the occurrence of aggressive behavior, because negative emotions such as anger, hostility, anxiety, and tension can trigger aggressive behavior (Roberton et al., 2012). This study hypothesized that societies with more forest resource have fewer aggressive behaviors.

Coastline vicinity (as calculated by dividing coastline length by land area), indicating the mean distance from the continent to the ocean, is also an important natural environmental factor influencing human behavior. Coastal and offshore areas have relative milder climates and much wider space for human activities than inland areas. Literature shows that people living in comfortable climates are less likely to experience physiological arousal (Anderson et al., 1997). At the seaside (e.g., sandy beaches), people can easily find open areas to interact with others, thereby satisfying the need for affiliation and establishing beneficial interpersonal relationships (Oishi et al., 2015; Stieger et al., 2022). Compared to coastal environments, mountain areas are not attractive to individuals who are agreeable or extravert (Götz et al., 2020). These individuals are more likely to live in coastal and offshore areas (e.g., Jokela et al., 2015). Previous literature found a stable negative correlation between agreeableness and aggressive behavior, while the relationships between other personality traits and aggressive behavior were inconsistent (Jones et al., 2011; Hosie et al., 2014). Therefore we hypothesized that coastal societies had fewer aggressive behaviors than landlocked societies.

Water is a key indicator of livability. Indeed, precipitation may have played a key role in culture evolution (e.g., Van de Vliert et al., 2018; Van de Vliert and Van Lange, 2019). Severe drought hampered crop growth and resulted in food shortages (Abel et al., 2019). As a result, less rainfall led to persistent violent clashes, especially in underdeveloped societies (Von Uexkull et al., 2016). Therefore, we hypothesized that societies with more rainfall have fewer aggressive behaviors than drier societies.

The effects of high altitude on social behavior tend to be negative, because high altitude can hamper human psychological functioning. At high altitude people are more likely to show behavioral and cognitive disturbances, severe depression and anxiety,and bipolar disorders (e.g., Bahrke and Shukitt-Hale, 1993; Kious et al., 2019). Literature shows that irritable and aggressive moods were very likely to develop at high altitude (Bahrke and Shukitt-Hale, 1993). At high altitude areas, human empathic abilities can be severely damaged. And moral judgment also becomes difficult because humans are costumed to behave in places close to the sea level (Banasiewicz et al., 2014). Therefore, this study hypothesized that there were more aggressive behaviors in high altitude societies compared with in low altitude societies.

These findings suggest that natural environmental factors and temperature can jointly influence aggressive behavior (Van de

Vliert and Conway, 2019). Based on existing literature, this study put forward two main hypotheses:

> *H1*: Heat demands, cold demands, and natural environmental factors influenced aggressive behavior at national level.
>
> *H2*: Natural environmental factors played moderating roles in the associations between heat and cold demands and aggressive behavior at national level.

Materials and methods

This study used previously aggregated population-level mean scores that are publicly available. Society (a country or region that has its own government) is the unit of analysis. These scores have been analyzed by other researchers (e.g., Van de Vliert, 2011, 2013a; Van de Vliert and Daan, 2017) and have been proved valid. Cold demands and heat demands were used as two independent variables. Aggressive behavior, as indicated by intergroup conflict, was the dependent variable. Sunlight, forest resource, coastline vicinity, rainfall, and altitude were mainly used as moderators though their main effects on aggression were also the research interest of this study. We first acquired the scores of temperature and aggression for 156 societies from Van de Vliert (2011, 2013a), then collected the population-level scores of other variables for these societies.

Cold demands and heat demands

Cold demands and heat demands were calculated using mean temperature of major cities in each country, weighted by population. We used the dataset provided by Van de Vliert (2013b).

Rainfall

Data for average monthly rainfall of each country were obtained from the World Bank Climate Change Knowledge Portal.[2] The data was first averaged across year (2009 to 2018), then the grand mean of rainfall (mm) of each country were calculated.

Sunlight and Forest resource

The grand mean of solar radiation (100 kw·h/m^2) of each country during 1991–2010 was used as an indicator of sunlight. Data were obtained through the weather information inquiry software (Meteonorm version 7) access to the worldwide irradiation data.[3] Latitude and longitude of each society were determined according to Van de Vliert and Van Lange (2019), and Google Maps. Data for forest resource of each society, as indicated by forest-to-land area ratio, was collected during 2009 to 2016 and averaged across years. The data was provided by the United Nations Food and Agriculture Organization (FAO) on the website of the World Bank.

Coastline vicinity and altitude

Coastline vicinity was calculated by dividing coastline length by land area of a society. The ratio indicates the average distance from land area to seashore. Data were obtained from the World Factbook published by the Central Intelligence Agency.[4] Data for altitude of each society was also obtained from the CIA World Factbook. This study used the average altitude (m) of each society as an indicator.

Aggressive behavior

This study used the intergroup conflict indicator developed by Van de Vliert and Daan (2017) as the measure of national level aggression. This indicator was the average of some standardized national level measures: the index of domestic conflict and violence,[5] press repression (Van de Vliert, 2011), and business costs due to crime and violence. These measures involved interpersonal aggression and violence, and intergroup conflict, such as political violence, war, and riot.

Literature shows that the world's climate changes are negligibly for millennia. This warrants the use of different sources of data with slightly inconsistent time span (Van de Vliert et al., 2018). Expectation maximization imputation approach was used to replace a small amount of missing values. Finally, the valid sample included 156 societies. SPSS (Version 26) was used in correlation analysis. The PROCESS macro for SPSS (model 1, Hayes, 2013) was employed to estimate the moderation models using 5,000 bootstrap samples.

Results

Correlation among research variables

Correlation among research variables were calculated (Table 1). The results showed that: (1) Cold demands significantly

2 https://climateknowledgeportal.worldbank.org/general-resources

3 https://meteonorm.com/

4 https://github.com/factbook/country-profiles

5 http://www.visionofhumanity.org/#/page/indexes/global-peace-index/2010

TABLE 1 Correlations among research variables (N=156).

variable	M	SD	1	2	3	4	5	6	7
1. Cold demands	37.15	25.95							
2. Heat demands	21.54	7.82	−0.58***						
3. Sunlight	17.02	3.88	−0.68***	0.57***					
4. Forest resource	28.36	21.07	−0.03	−0.26**	−0.28***				
5. Coastline vicinity	26.16	83.61	−0.12	−0.03	−0.08	−0.12			
6. Rainfall	87.47	59.65	−0.45***	−0.10	−0.05	0.56***	0.14		
7. Altitude	627.93	565.97	0.12	−0.22**	0.23**	−0.12	−0.20*	−0.15	
8. Aggression	0.0026	0.78	−0.34***	0.25**	0.54***	−0.14	−0.25**	0.02	0.31***

*p < 0.05, **p < 0.01, and ***p < 0.001.

and negatively correlated with aggressive behavior; (2) Heat demands significantly and positively correlated with aggressive behavior; (3) Sunlight significantly and positively correlated with aggressive behavior; (4) Coastline vicinity significantly and negatively correlated with aggressive behavior; (5) Altitude significantly and positively correlated with aggressive behavior; These results suggest that thermal demands and natural environmental factors both are associated with national level aggression.

Moderation effects of natural geographical environment

To explore how the joint effects of temperature and environmental factors on aggressive behavior, we used both cold demands and heat demands as independent variables, and five natural environmental variables as moderators. The results were shown in Table 2.

Model 2 showed that forest resource had a significant moderating effect on the relationship between cold demands and aggressive behavior (the interaction of cold demands and forest resource was significant: $\beta = -0.18$, $t = -2.50$, $p = 0.014$, 95% confidence interval, CI: [−0.33, −0.04]). Simple slope analysis showed that the negative effect of cold demands on aggressive behavior was significant in the high forest resource condition (high = 1 SD above the centered mean; low = 1 SD below the centered mean; $\beta = -0.50$, $t = -5.14$, $p < 0.001$, 95% CI: [−0.69, −0.31]); whereas in the low forest resource condition the negative influence of cold demands on aggressive behavior was not significant ($\beta = -0.13$, $t = -1.11$, $p = 0.27$, 95% CI: [−0.35, 0.10]). See Figure 1 for details. These results suggested that with the increase of forest resource, the negative effect of cold demands on aggressive behavior was enhanced.

Model 3 showed that coastline vicinity had a significant moderating effect on the relationship between cold demands and aggressive behavior (the interaction term of cold demands and coastline vicinity was significant: $\beta = -0.32$, $t = -2.18$, $p = 0.03$, 95% CI: [−0.61, −0.03]). Simple slope analysis showed that the negative effect of cold demands on aggressive behavior was significant in the high coastline vicinity condition ($\beta = -0.73$, $t = -4.08$, $p < 0.001$, 95% CI: [−1.08, −0.38]). In the low coastline vicinity condition, the negative influence of cold demands on aggressive behavior was still significant ($\beta = -0.31$, $t = -3.96$, $p < 0.001$, 95% CI: [−0.46, −0.15]), but the regression coefficient was much smaller (Figure 2). These results suggested that in societies near the sea, cold demands can more strongly reduce aggressive behavior.

Model 4 showed that rainfall had a significant moderating effect on the relationship between cold demands and aggressive behavior (the interaction term of cold demands and rainfall was significant: $\beta = -0.36$, $t = -3.36$, $p = 0.001$, 95% CI: [−0.57, −0.15]). Simple slope analysis showed that the negative effect of cold demands on aggressive behavior was significant in the high rainfall condition ($\beta = -0.90$, $t = -5.41$, $p < 0.001$, 95% CI: [−1.23, −0.57]). In the low rainfall condition, the negative influence of cold demands on aggressive behavior was not significant ($\beta = -0.17$, $t = -1.55$, $p = 0.12$, 95% CI: [−0.38, 0.05]), see Figure 3. These results suggested that with the increase of rainfall, the negative effect of cold demands on aggressive behavior was enhanced.

These results suggested that some natural environmental factors played moderating roles in the relation of temperature and aggressive behavior. Surprisingly, heat demands did not show interaction effect with any of the environmental factors.

Discussion

Heat demands, cold demands, environmental factors and aggressive behavior

This study is aiming to investigate whether environmental factors influence aggression and the temperature-aggression association, which is substantially fulfilled. Consistent with Hypothesis 1, this study found that heat demands, cold demands, and some natural environmental factors were significantly associated with aggressive behavior at national level. A significant positive correlation between heat demands and aggressive behavior was consistent with previous studies (e.g., Rotton and Cohn, 2003; Larrick et al., 2011; Hsiang et al., 2013). Anderson et al. (1997) posits that situational variables (e.g., high

TABLE 2 Moderating effects analysis (N=156).

	Regression equation		Significance of coefficient		Significance of model	
	Outcome	**Predictor**	β	95%CI	R^2	F
Model 1	Aggression	Constant	0.01	[−0.17, 0.19]		
		Cold demands (CD)	0.07	[−0.12,0.26]		
		Sunlight	0.58***	[0.39,0.78]		
		CD× Sunlight	0.02	[−0.16, 0.19]	0.30	21.62***
Model 2	Aggression	Constant	−0.01	[−0.15, 0.14]		
		Cold demands (CD)	−0.31***	[−0.46, −0.16]		
		Forest resource (FR)	−0.18*	[−0.33, −0.04]		
		CD × FR	−0.18*	[−0.33, −0.04]	0.17	10.45***
Model 3	Aggression	Constant	−0.04	[−0.18, 0.11]		
		Cold demands (CD)	−0.41***	[−0.56, −0.26]		
		Coastline vicinity (CV)	−0.48***	[−0.70, −0.26]		
		CD × CV	−0.32*	[−0.61, −0.03]	0.22	14.65***
Model 4	Aggression	Constant	−0.16	[−0.33, 0.01]		
		Cold demands (CD)	−0.53***	[−0.71, −0.36]		
		Rainfall	−0.40***	[−0.61, −0.19]		
		CD× Rainfall	−0.36**	[−0.57, −0.15]	0.20	12.29***
Model 5	Aggression	Constant	−0.004	[−0.14, 0.14]		
		Cold demands (CD)	−0.38***	[−0.52, −0.23]		
		Altitude	0.34***	[0.19, 0.50]		
		CD× Altitude	0.04	[−0.11, 0.18]	0.24	16.09***
Model 6	Aggression	Constant	−0.02	[−0.18, 0.14]		
		Heat demands (HD)	−0.10	[−0.29,0.08]		
		Sunlight	0.61***	[0.42,0.80]		
		HD× Sunlight	0.03	[−0.13, 0.19]	0.30	21.98***
Model 7	Aggression	Constant	0.01	[−0.15, 0.17]		
		Heat demands (HD)	0.24**	[0.07, 0.40]		
		Forest resource (FR)	−0.09	[−0.25, 0.07]		
		HD × FR	0.05	[−0.11, 0.21]	0.07	3.86*
Model 8	Aggression	Constant	0.004	[−0.15, 0.15]		
		Heat demands (HD)	0.26**	[0.10, 0.41]		
		Coastline vicinity (CV)	−0.21*	[−0.38, −0.04]		
		HD × CV	0.12	[−0.17, 0.41]	0.13	7.22***
Model 9	Aggression	Constant	−0.003	[−0.16, 0.15]		
		Heat demands (HD)	0.25**	[0.09, 0.41]		
		Rainfall	0.05	[−0.11, 0.21]		
		HD× Rainfall	−0.03	[−0.19, 0.13]	0.06	3.52*
Model 10	Aggression	Constant	−0.007	[−0.16,0.14]		
		Heat demands (HD)	0.32***	[0.15,0.49]		
		Altitude	0.37***	[0.19,0.55]		
		HD× Altitude	−0.03	[−0.27, 0.21]	0.20	12.91***

*p <0.05, **p <0.01, and ***p <0.001.

temperature) and individual variables (e.g., genetic characteristics, trait aggression, attitudes towards violence) together affect a person's aggressiveness. In hot weathers individuals experience high physical arousal, which triggers more aggression. The Routine Activity Theory (Rot and Cohn, 2001) suggests that crime rates are higher in summer because there are more interpersonal interactions during hot months.

The inhibitory effect of coldness on aggressive behavior can be explained by life history theory (Hill, 1993). Lower temperature, and especially larger degrees of seasonal variation in climate, call for individuals and groups to adopt a slower life history strategy: a greater focus on the future (vs. present), and a stronger focus on self-control. These characteristics of individuals are important factors in curbing aggression and violence (Van de

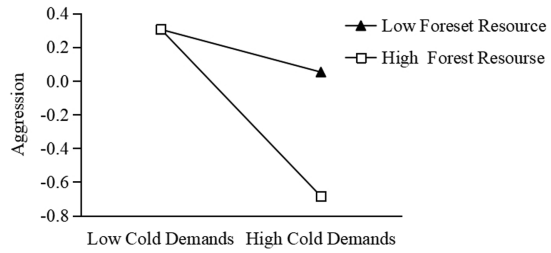

FIGURE 1
The moderating effect of forest resource in cold demands and aggression.

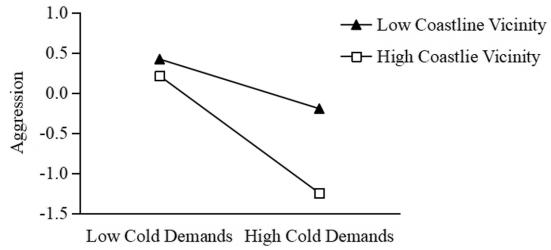

FIGURE 2
The moderating effect of coastline vicinity in cold demands and aggression.

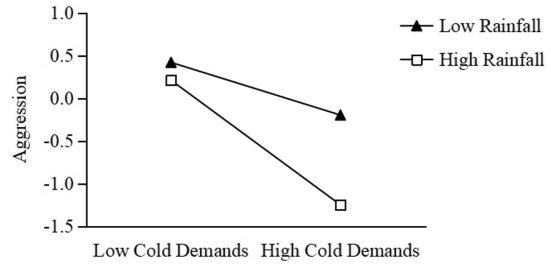

FIGURE 3
The moderating effect of rainfall between cold demands and aggression.

Vliert and Daan, 2017). Another explanation for this result is that people interact less frequently at colder (vs. hotter) weather, decreasing the incidence of aggressive behavior (Rotton and Cohn, 2003).

Sunlight was significantly and positively related to aggressive behavior. One possible reason is that the temperature is relatively high in areas with more sunlight (in this study the correlation coefficient of sunlight and cold demands is −0.68; the correlation coefficient of sunlight and heat demands is 0.57, $ps < 0.001$). Another explanation is that sunlight can enhance negative behavior (e.g., Esteky et al., 2020). Psychiatric studies have found that sunlight may interact with serotonin neurotransmission in triggering impulsivity and suicide (e.g., Vyssoki et al., 2012).

Altitude was significantly and positively related to aggressive behavior. This is consistent with findings that irritable and aggressive emotions are more likely to develop at high altitude (Bahrke and Shukitt-Hale, 1993). At high altitude, human empathic ability can be severely damaged, and moral judgment of behavior becomes difficult (Banasiewicz et al., 2014). The negative physiological responses (e.g., Frisancho, 1993) in high altitude suggest that people are more likely to experience negative emotions and behavioral impulsiveness, which are associated with more aggression.

There was a significantly negative correlation between coastline vicinity and aggressive behavior. That is, coastal societies have less aggression than landlocked societies. This reason may be that the coastal regions are better in meeting people's needs for affiliation (live with others, cooperate, and interact socially with others) and thereby promoting positive interpersonal relationships (Oishi et al., 2015). In other words, coastal environment can reduce the incidence of destructive interpersonal relationships (Jones et al., 2011; Hosie et al., 2014).

However, forest resource and rainfall were not significantly associated with aggressive behavior. This is inconsistent with Hypothesis 1. The possible reason may be that their effects on aggression are more complicated. Although Hypothesis 1 was only partially supported, this study proved that temperature and natural environmental factors indeed influence the national level aggression.

The moderating effects of environmental factors

Partly consistent with Hypothesis 2, this study found that coastline vicinity, rainfall, and forest resource moderated the relationship between temperature and aggressive behavior. These results deepened the understanding of the relationship between natural environment and aggressive behavior. This lends more support for the effects of geographical factors on human psychology and behavior (Van de Vliert and Van Lange, 2020).

Firstly, forest resource reinforced the negative impact of coldness on aggressive behavior. That is, forest can enhance the negative effect of cold on aggressive behavior. This may be because that the comfort bring by forest (e.g., Ikei et al., 2017; Song et al., 2019) can further reduce disruptive interpersonal interactions. Coldness restrains aggressive behavior by reducing social interactions (Rotton and Cohn, 2003), and forest resource can reinforce this effect.

Secondly, coastline vicinity reinforced the negative impact of coldness on aggressive behavior. That is, in coastal (relative to landlocked) societies the negative impact of coldness on aggressiveness was much stronger. Greater productivity and

convenient transportation provided by the ocean contribute to economic prosperity (Rappaport and Sachs, 2003), therefore people are more willing to move to the seaside. Economic development can greatly improve human competence to overcome the survival challenges caused by adverse living conditions (Rappaport and Sachs, 2003). For coastal societies, the year-round variations in temperature are small and the climate is comfortable, these advantages can enhance the negative impact of coldness on aggression (Van de Vliert, 2013a).

Thirdly, rainfall enhanced the negative effect of cold on aggressive behavior. This is consistent with previous findings that rainfall together with other environmental factors can jointly affect conflict and violence (Van de Vliert and Daan, 2017). Rainy and cold weather restrains human interactions, thereby reducing aggressive behavior (Rotton and Cohn, 2003). In humid weathers people are more likely to engage in productive activities than social activities (Lee et al., 2014). However, this study did not find that sunlight and altitude can moderate the relationship between cold demands and aggressive behavior.

Finally, this study did not found moderating effect of natural geographical factors on the relationship between heat demands and aggressive behavior. This might be due to the fact that coldness has been the main threat to human survival for millions of years,while hot climates (i.e., heat demands) indirectly threatened survival through pathogen prevalence (Gurven and Kaplan, 2007; Murray, 2013; Van de Vliert and Conway, 2019). Human ancestors mainly lived in equatorial regions. Until the utility of fire humans began to expand to colder climatic zones. The absence of moderation effects of natural geographical environmental factors may confirm the proposition that the threats posed by pathogen prevalence cannot be alleviated by others factors (e.g., Van de Vliert and Van Lange, 2019).

Findings of this study may have practical implications in reducing the occurrence of dangerous incidents. For example, large scale crowd gathering during hot summer months should be avoided. Large group activities are encouraged to be hold at low altitude or cooler areas, or in coastal and humid areas. In public places measures are encouraged to be adopted to relieve heat and increase humidity artificially to reduce aggression (Von Uexkull and Buhaug, 2021).

Limitations and future directions

This study examined the main effects of several geographical factors, as well as their moderating effects in the association between temperature and aggression. These findings lend more support for the geographical hypothesis of psychological phenomena, improving the understanding of national level variations in human psychology and behavior. However, limitations of this study have to be addressed. One significant limitation is that we adopted a convenient sampling method. That is, this study only includes countries that can provide aggregated data. Generalizability of our findings is questionable. Furthermore, findings of this study need to be soundly confirmed in strictly controlled laboratory settings (Gelfand and Lun, 2013) in order to determine the causal link between geographical factors and psychological variables.

Conclusion

Base on national level data this study found that temperature is a significant predictor of aggressive behavior. Cold demands (temperature lower than the reference point) predict less aggression; while heat demands (temperature higher than the reference point) predict more aggression. A society's sunlight and altitude were significantly and positively related to aggressive behavior; while coastline vicinity was significantly and negatively related to national level aggressive behavior. Forest resource, coastline vicinity and rainfall reinforced the negative impact of cold demands on aggressive behavior. That is, in regions closer to ocean, with more forest resource, and with more rainfall, coldness has stronger weakening effect on aggressive behavior.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

QG and JS wrote the original manuscript. SL, JS, and JL collected and analyzed the data. QG and SL revised the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Environmental integration tool approach: Self-determined commitment and the adoption of pro-environmental behaviors

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This paper discusses the role of self-determined commitment in the methodological dynamics of the Environmental Integration Tool Producer (EIT Producer) and its potential impact on the adoption of pro-environmental behaviors by local economy actors in the Global South. This tool is part of the EIT Approach developed by Louvain Coopération, the NGO associated with Université Catholique de Louvain (Belgium), which aims to support social actors in productivity and consumption activities in Africa, Andean America, and Asia. The aim is to highlight the conceptual and methodological elements of the OIE Producer, in order to understand the role of self-determined commitment in the expected ends and in the impact of the tool. The integration between economic development and the environment is a central issue in the challenges of contemporary global society. This article intends to contribute with answers to such challenges, especially with regard to the development of methodologies that are effective in governmental and non-governmental cooperation programs engaged for sustainable development.

KEYWORDS

environmental integration tool approach, self-determined commitment, environmental behavioral intention, pro-environmental behavior, global south local economy actors, Belgian development cooperation, sustainable development

Introduction

In a global context, where the environment is at the heart of national and international agendas, governmental and non-governmental, the NGO associated with Université Catholique de Louvain (Belgium), Louvain Coopération, part of the Belgian development cooperation, began to build in 2011 a methodology for environmental integration called Environmental Integration Tool/ETI Approach (*Approche Outil d'intégration Environnemental – Approche OIE*). The EIT Approach offers a systematized transversality (although not mandatory) of the environmental theme in every phase of the Project Cycle Management. It consists of two tools – the EIT Program and the EIT Producer – created by Louvain Coopération to better meet the needs and objectives of its Food and Economic

Security/FES Program projects by systematically taking into account their relationship with the environment. It is anchored in development principles according to which economic, social, and environmental aspects are inseparable and interdependent, and on research-intervention principles, that combines knowledge production, the transformation of social realities and the reinforcement of individual and social skills (Faure, 2010). The EIT-Program is implemented at the macro-level of a project/program and involves an analysis by the management team. The goal is to identify potential reciprocal relations between a project/program and its environment. The EIT Producer is designed to structure the dialogue between an economic agent who is responsible for a productive activity supported by a project/program (the Food and Economic Security Program, or others) and the management team of this program. However, it may also be employed by an unsupported economic agent, as an exercise of self-analysis. This economic agent may be an individual, a family, a group, an association, a cooperative, a local authority etc.

The EIT Approach was validated in 2019 from a participatory and multi-actor process (Henin and Uglione, 2021). The relevance and originality of the EIT Approach is recognized by different Belgium cooperation institutions like ARES (Académie de recherche et d'enseignement supérieur), VLIR-UOS, ACODEV (Fédération des Organisations de la société civile de Coopération au développement) but mostly DGD (Direction générale Coopération au Développement et Aide humanitaire). Built for the economic sector, it has also be adapted to Education sector by Educaid. Under the Food and Economic Security Program/FES, the application of the 1015 EIT Producer resulted in 1049 self-determined commitments by the local producers. Some examples of these commitments can be seen in initiatives in Benin, such as crop rotation, composting and usage of organic inputs and pesticides, integrated management of crop pests and diseases, reforestation, the use of living hedges and many others. In this country, this application generated 794 pro-environmental actions, which represents 77.31% of the commitments. The application of the EIT-Producer in Togo generated 89 pro-environmental actions by economic agents, which corresponds to 82% of the total self-determined commitments undertaken by these actors.

At this stage of development, a Document Analysis of the material of Louvain Coopération was proposed in 2020 with the objective of compiling the experience of creating these tools and assessing its impact, both for the consolidation of its practices and for the legitimization of the methodology disseminated. This research had as its historical boundary the period between the time of the launch of the EIT Approach in 2012–2020, when the mid-term evaluations of the 2017–2021 Food and Economic Security program were completed.

This paper presents the results of a qualitative research based on Documentary Analysis of materials on the EIT Approach with a focus on the methodological aspects of the EIT Producer variant. The aim is to discuss the role of self-determined commitment in the methodological procedures of the EIT Producer in order to identify the potential of the EIT Approach to influencing the adoption of pro-environmental behaviors by local economy actors. The purpose is to contribute to discussions about the methodologies of environmental integration in development cooperation programs and their impact on behavioral changes concerning the environment in the contexts where they are implemented.

Framework

Development cooperation

The origin of Belgian development cooperation is contemporary with the decolonization process after World War II, supported by the international instances of the United Nations. Since its beginning, Belgian development cooperation has been subject to criticism, several crises and political reforms (Contor, 2017). At the end of the 90s, a structural and political reform led to a major transformation of the sector. The Law on Belgian international cooperation (Kingdom of Belgium, 1999) clarifies the general objectives of Belgian cooperation such as sustainable human development and a longer-term political vision. Among its effects, the May 1999 reform confirmed the legitimacy of Belgian NGOs (actors of non-governmental cooperation) as representative structures of civil society and committed to the fight against poverty. The Administration générale de la Coopération au développement (now Direction générale Coopération au Développement et Aide humanitaire/DGD) presented a series of recommendations specific to the NGO sector. Among them, the strengthening of their social base, and the need to adopt a coherent approach and to work in complementarity with other actors. At the international level, NGOs are also becoming key actors in development cooperation (Charnovitz, 2002). NGOs are very important actors in Belgian cooperation, implementing development programs in the South or in Belgium (Molenaers et al., 2011). From 2013 onwards, environmental protection must permeate all interventions of the Belgian development cooperation (Law on Development Co-operation, Kingdom of Belgium, 2013). In 2014, the integration of environmental protection in the sectors of education, health, basic infrastructure and agriculture was elected as a priority for Belgian development cooperation (DGD, 2014). This priority is justified by the expectations of the Belgian development cooperation regarding the sustainable development of its programs and projects, understood as what ensures a just transition toward sustainable production and consumption patterns (Law on Development Co-operation, Kingdom of Belgium, 2013). The impact of environmental integration in development cooperation must be measured in terms of its contributions to sustainable development, and experiences have shown that this integration can provide important inputs to programs and projects, but that can also face many constraints (Ledant, 2016). Among them, a simplified or "minimalist" vision of sustainable development, which reduces its goals in relation to

the current and future needs of societies. Also, the divergence between local and Northern environmental logics, particularly because the environmental impetus comes from donors and the integration orientations are based on Northern visions rather than on the rapports, desires and needs of Southern populations. This discrepancy gives environmental integration interventions an exogenous character, felt by the target populations in the South as intrusive and disturbing (Ledant, 2016). For the European Commission, the process of systematically integrating either a value, a theme or an idea into areas of cooperation requires changes in both ideas and practices. With regard to environmental mainstreaming, stakeholder participation is recognized as a key factor for sustainability in development cooperation (European Commission, 2011).

Environmental behavior change

Environmental issues related to productivity and consumption patterns are an enormous and multidimensional challenge. Changing the behavior of social actors is part of this challenge. A number of factors can influence human actions; people contribute to their life circumstances, instead of being only passive products of them (Bandura, 2006). Environmental behavioral intention refers to the willingness of the individual to act and consume in a more sustainable manner. Environmentally friendly behavior is largely shaped by behavioral intentions (Braksiek et al., 2021). For Davis et al. (2009), commitment to the environment is a very strong predictor of pro-environmental behavior. According to the Transtheoretical Model/TTM of Prochaska and DiClemente (1992), adapted by Bamberg (2013), behavioral change is a gradual and non-linear process. Behavioral change intention is a crucial part of this process and depends on convincing arguments about the benefits of change (Richter and Hunecke, 2020). This process implies the passage of the individual through phases in which he/she has doubts regarding the advantages of change or his/her capacity to change. The intention to change has the function of a cognitive action plan by which the individual tries to eliminate or significantly reduce his doubts and ambivalence about the change and the new behavior to adopt (Prochaska and DiClemente, 1992). According to the Theory of Planned Behavior/TPB, by Ajzen (1991, 2011), individuals make reasoned decisions and this behavior is the result of the intention to engage in it. The intention to act is the direct antecedent of behavior (Ajzen, 1991). It constitutes the cognitive representation of a person's willingness to adopt a certain behavior (Ajzen, 1991). Through intention, the individual foresees the consequences of his actions before deciding on taking them. Intention depends on three variables: attitudes toward the behavior, i.e., positive or negative perceptions of future behavior; subjective norm, or perceived social pressure; and perceived behavioral control, which provides a sense of how easy or difficult it is to perform the behavior (Ajzen, 1991). Other motivational factors such as personal norms and identity can also affect environmental intention behavior (Nigbur et al., 2010). The intention is an important predictor of people's ecological behavior, and the stronger the intention, the more effort an individual will make to adopt pro-environmental behavior (Steg and Nordlund, 2013). Intention to act is a determinant of behavior toward the environment (Farrow et al., 2017). Regarding energy conservation there is a strong correlation between intention to act and real behavior (Macovei, 2015). The same is true for everyday behaviors such as turning off lights (Levine and Strube, 2012). A TPB-based study run in Saudi Arabia about the influencing factors on the intention to consume has found that environmental concerns, subjective norms, and attitudes were significant predictors of individuals' adoption of hybrid electric vehicles (Alzahrani et al., 2019). These results are consistent with those of Lee et al. (2021) in Pakistan. The results of another study on the ecological behavior of biology professors showed that their knowledge of environmental issues indirectly influences their behavior through the intention to act (Iman et al., 2019). This is measured by the desire to protect the environment. Similar findings emerged from a study by Gkargkavouzi et al. (2019), which shows that knowledge could indirectly drive behavioral change by affecting the intention to engage in conservational efforts and could therefore be used to predict behavioral intention and environmental behavior. Research based on a cross-national social survey of 36 countries has shown that risk perception is a predictor of intention to act for the environment and that low-income people view the potential environmental consequences of human interventions as extremely dangerous, more so than high-income people (Lo, 2014).

Materials and methods

Historical context

Between 2011 and 2019, Louvain Coopération has developed as a part of its Food and Economic Security program a specific approach to systematically take into account the environment in its interventions, translated into two Environmental Integration Tools (EITs): the EIT-Program and the EIT-Producer, registered under a Creative Commons License (CC BY-SA: Attribution-ShareAlike). From a single variant tested in 2012 (EIT Approach version 1) through EIT Approach version 2/2015, EIT Approach version 3/2017, EIT Approach version 4/2018 and on to the final version validated in 2019 (EIT Approach version 5), an intense work of progressive improvements has been implemented after a process of field experiments (in African countries – Benin, Burundi, Madagascar, Congo and Togo -, in Andean America – Bolivia and Peru – and in Asia – Cambodia – where Louvain Coopération operates) and internal and external exchanges, with multiple actors, especially those of the Belgian development cooperation (Henin and Uglione, 2021). The EIT Approach has been the subject of an intense dissemination campaign in the Belgian development cooperation but also in academia. By the time the mid-term evaluations of the Food

and Economic Security program 2017–2021 were finalized, the IET Approach had been disseminated in all ongoing Food and Economic Security program over the 2017–2020 period and in other institutions. This large-scale diffusion has been fundamental for the continuous improvement of the EIT Approach, but also for the formation of staff who, in addition to mastering its approach and its tools, have appropriated them in a creative way (Henin and Uglione, 2022).

Document analysis

Document Analysis is a method of data collection used in different fields of research as a supplement to other methods or as a primary method (Coustaty et al., 2011; Metag et al., 2016; Cardno, 2018; Price et al., 2021 and others). The material used in a Document Analysis can be in printed or electronic format (Fischer, 2006). This provides a very wide applicability to this method, and this is one of its advantages (Bowen, 2009). The great diversity of documents generally available to a researcher should be used to benefit the credibility of his or her research. This diversity is especially important in expanding the contextual variables of the data (Price et al., 2021). Documents are stable and "non-reactive" data sources (Bowen, 2009). They can be reviewed repeatedly without being transformed by the research process itself. However, this stability requires a lot of work in compiling and interpreting the information, which sometimes depends on a much broader investigation than initially expected, with the inclusion of additional documents (Bowen, 2009). Document Analysis requires revised planning throughout the research process, as having an evolving list of documents to explore; paying continuous attention to the peculiarities and possible language or cultural barriers of the documents, being current on the topics of the documents and taking into account ethical issues (such as document confidentiality; O'Leary, 2014).

Process

In what socio-historical context was the EIT Approach conceived? Who were the main actors in this process? What ideas and concepts have guided its different versions? How was it disseminated internally and externally? What are the impacts of this innovation on Louvain Coopération's programs and areas of intervention? Based on these initial research questions, five categories were established to guide the selection of documents:

A. Materials concerning the construction process of the EIT Approach;
B. Materials concerning the diffusion and appropriation process and impact of the EIT Approach;
C. Versions and variants of the EIT Approach;
D. Food and Economic Security/FES program reports and
E. Others.

A total of 46 documents from the virtual library of Louvain Coopération were analyzed. The selection of documents was based on the principle of saturation (Saunders et al., 2018). A list of these documents is presented in Table 1.

Initially, this material was read superficially in order to gain a better understanding and sensitivity to the vocabulary and context in which the documents were produced (Altheide, 2000). This was followed by a process of immersion, reading and re-reading of the documents until familiarity with the data was achieved (Bowen, 2009). This immersion allowed the classification of the documents according to their most relevant themes. The guiding/initial questions of the research were always kept as a reference (Lincoln and Guba, 1985). From this classification emerged three main analytical axis:

- Axis 1 – The construction of the EIT Approach.
- Axis 2 – The diffusion and appropriation of the EIT Approach.
- Axis 3 – The impact of the EIT Approach.

The documents were read several times, as part of an inductive work to identify relevant topics based on the information contained in those documents, as well as on the practical and theoretical knowledge of the researchers (Jodelet, 2003). This led to the emerging of leads that guided the definition of categories which guided the analysis within each axis in a more straightforward manner. Within each axis, a lexical approach to Textual Data Analysis guided the grouping of information based on what it says (Moscarola, 2018). This grouped information was described, and finally, a synthesis of each axis was constructed from inferences of this information.

Results

Conceptual and methodological aspects of EIT producer

The results concerning the conceptual and methodological aspects of the EIT Producer were found mainly in the analyses in Axis 1. The most important documentary sources for this analysis were:

1. Materials concerning the construction process of the EIT Approach;
2. Versions and variants of the EIT Approach and
3. Others.

The construction of the EIT Approach was a large and gradual process, from a single tool to a version with two tool variants, the EIT Program and the EIT Producer. Successive changes in form, content and methodological aspects were made throughout the process of developing the approach. Multi-stakeholder

TABLE 1 List of documents.

Category	Title
A	01 Synthèse de Mémoire
	02 Stratégie de Visibilité et Reconnaissance
	03 Stage Salima Kempenaer en Bolivie
	04 Manuel d'Intégration Environnementale/Union Européenne version 2006
	05 Manuel d'Intégration Environnementale/Union Européenne version 2009
	06 Outil Klimos
	07 Mission de l'Assistante Junior Delphine Latinis en Amérique Andine
	08 Rapport de Mission au Bénin
	09 Communication Interne Louvain Coopération
B	10 Formation donnée lors du Stage Méthodologique en Conception de Projets pour le Développement Durable/Sénégal, RDC, Bénin, Burkina et Haïti
	11 Présentation/Agricongo, 2017
	12 Formation/l'ONG syndicale MSI, 2018
	13 Présentation (Solidarité Internationale pour le Développement et l'Investissement-SIDI/France et Société Wallonne de Financement-Sowalfin), 2019
	14 Présentation lors de la mission de Vincent Henin à Madagascar, 2018
	15 Présentation à l'Université de Parakou, 2019
	16 Rapport Formation Burundi
	17 Méthodologie Formation Burundi
	18 Intégration de la Préoccupation Environnementale en Coopération au Développement/Présentation
	19 Schéma Programme DGD 2022–2026
	20 Synthèse Réunion Louvain Coopération avec l'Association Belge APEFE
C	21 Approche Outil d'intégration Environnemental – Présentation
	22 Outil d'Intégration Environnementale version 1
	23 Outil d'Intégration Environnementale version 2
	24 Méthodologie de l'Outil d'Intégration de l'Environnement dans le Programme SAE de Louvain Coopération
	25 Outil d'Intégration Environnementale au Niveau Institutionnel version 3
	26 Outil d'Intégration Environnementale au Niveau des Bénéficiaires version 3
	27 Méthodologie de l'Outil d'Intégration Environnementale au Niveau Institutionnel version 3
	28 Méthodologie de l'Outil d'Intégration Environnementale au Niveau des Bénéficiaires version 3
	29 Outil d'Intégration Environnementale Programme/OIE-Programme – version 4
	30 Outil d'Intégration Environnementale Producteur/OIE-Producteur version 4
	31 Approche Outil d'Intégration Environnemental/OIE Programme version 5
	32 Approche Outil d'Intégration Environnemental/OIE Producteur/Productrice version 5
D	33 Rapport Narratif AMSANA
	34 Rapport d'Évaluation à Mi-parcours SAE Uni4Coop Bénin
	35 Rapport d'Évaluation à Mi-parcours SAE Uni4Coop Bolivie
	36 Rapport d'Évaluation à Mi-parcours SAE Uni4Coop République Démocratique du Congo
	37 Rapport Interne SAE République Démocratique du Congo
	38 Rapport Interne SAE Madagascar
	39 Rapport Interne SAE Bénin
	40 Rapport Interne SAE Bolivie
	41 Rapport Interne SAE Togo
E	42 Synthèse du Chantier
	43 Synthèse Réunion Version 3
	44 Liste OIE Remplis au Sein de Programmes SAE
	45 Rapport Mensuel du Programme Petit Entreprenariat Rural 2 (fourni par ULB-Coopération à Louvain Coopération)
	46 Synthèse Mission Outils d'Intégration Environnementale-OIE au Siège

participation and field experimentation were the basis for this process. Why create a new methodology for environmental integration? Louvain Coopération's ambition was to develop an approach that would play an important role in the conception of programs/projects (concepts, objectives, etc.), rather than being a tool focused on their evaluation. A practical methodology, capable of being a source of information and education. In addition, this new approach should drive a systematic environmental integration, present in all phases of a project/program. The first version of the EIT Approach was launched in 2012 as a single questionnaire where the questions are articulated around two main pillars:

1. Influences of the environment on projects and
2. Influences of project's actions on the environment.

The content analysis of these questions shows ideas regarding the intrinsic link between environmental, social, and economic factors (poverty and others), forces underlying environmental pressures (legal issues, job opportunities, and others) and groups particularly vulnerable to environmental issues. "*Was the environment properly taken into account in the initial diagnosis of the problems to be solved?*" (question number 1 from Outil d'Intégration Environnementale version 1, page 1, doc. 22 – List of Document). In this question, the methodological strategy is not only to ask whether the environment is taken into account in the diagnosis phase. The goal is to stimulate reflection on the importance of taking it into account. This is a methodological perspective in which the data collection on the environmental actions/behaviors of the actors is combined with the stimulus to the reflexivity of these actors concerning these actions/behaviors.

"*The tool* [Environmental Integration Tool, now EIT Approach] *can be compared to a common thread in order to improve the reflections and decision making at every phase of the Project Cycle*" (Méthodologie de l'Outil d'Intégration de l'Environnement dans le Programme SAE de Louvain Coopération, page 1, doc. 24 – List of Document).

This and other explanations emphasize the transversality of the integration envisaged by the approach and the methodological dynamic through which it must be achieved, i.e., provoking the reflection that will lead to a decision.

The 2015 version has been tested extensively through the FES program. This process resulted in the third version, launched in 2017, with two variants: EIT Institutional and EIT Beneficiary. This innovation reflects the difference between a tool designed for those who manage projects and a tool developed for those whom these projects are intended to reach, actors in local economy (individuals, families, associative groups, etc.), participants of the FES program.

This version presents substantial changes. In both variants, concepts of sustainable development and environmental protection are added, as well as a more detailed contextualization of the expectations of the tools. The semi-structured questionnaire remains the basis for both variants, but the structure (the steps and the content of the questions) and the methodology are different in each one. The EIT Institutional reproduces the dynamics of the previous version. This application covers all phases of the Project Cycle Management (identification, formulation, implementation and evaluation). In the EIT Beneficiary, the application takes place only in the implementation phase and is intended to be accomplished in four stages: Environmental Diagnosis, Diagnostic Analysis, Self-Determined Commitment, and Implementation of Commitment.

> "*They* [EIT Institutional and EIT Beneficiary] *offer us two different points of view, the EIT Beneficiary arises from a shortcoming of the EIT-Institutional, which only takes into account the vision of the technicians of the project and not the vision of the beneficiaries*" (Synthèse réunion version 3, np, doc. 43 – List de Document).

> "*The 3rd stage concerns the commitments from the beneficiary. A second interview is proposed to him to discuss the results of the analysis* [Diagnostic Analysis] *and to and to establish the pro-environment commitments*" (Méthodologie de l'Outil d'Intégration Environnementale au Niveau des Bénéficiaires, page 3, doc. 28 – List of Document).

The self-determined commitment is therefore integrated into this third version, as a step after the analysis work, and carried out through an interview between the team managing the project and the beneficiary (an agent of the local economy).

In the 4th version, of 2018, the EIT Beneficiary becomes EIT Producer. The collective and dialogical dynamic behind its methodology is highlighted in this version.

> "*This tool* [EIT Producer] *is designed to structure a dialogue, a reflection at the environmental level between an economic actor responsible for a productive activity supported by one of our projects/programs, and the technical team of the project/program*" (Outil d'Intégration Environnementale/OIE-Producteur version 4, page 2, doc. 30 – List of Document).

In 2019, a new version [current EIT Approach, with its two variants EIT Program and EIT Producer] is presented and the whole construction process reaches its stabilization. The steps of the EIT Producer become: Environmental Diagnosis (step 1), Commitments (of the economic agent, step 2) and Commitments Implementation (step 3). The Environmental Diagnosis is carried out through a semi-structured questionnaire, understood as a "reflection guide" used during a meeting between the technical team and the producer, or by the producer alone, in an exercise of self-reflection.

Self-determined commitments and Pro-environmental behavior

> "(…) *highlighting mutual effects between economic/productive activity and environment, the willingness of the economic agent to better take environmental issues into account, and his/her capacities and needs to commit to*" (Approche Outil d'intégration Environnemental – Présentation, page 3, doc. 21 – List of Document).

> "*The idea is to highlight the producer's knowledge and perceptions of the environment, as well as the main mutual relationships (positive or negative) between his activity and the environment.*" (Approche Outil d'Intégration Environnemental – OIE Producteur/Productrice version 5, page 3, doc. 32 – List of Document).

The topics/parts of the environmental diagnosis are:

- The terms of use: identification of the producer, description of possible third parties taking part in the diagnosis and their role (as observers, facilitators, etc.), and determination of who assigns the indicator scores;
- A brief description of the producer's activity;
- A brief description of the environmental context, which provides a baseline of the environmental situation in the activity or area;
- A brief description of the mutual effects between the environment and the producer's activity;
- A semi-structured questionnaire for themes:

1. The effects of the environment on the producer's activity;
2. The effects of the producer's activity on the environment;
3. The producer's willingness to commit for the environment and
4. The producer's capacities and needs to commit;

- A summary of all scores, as well as the main actions identified to improve the environmental situation of the activity and
- The lessons learned during this process, highlighting what the key actors gained from the diagnosis, and potential proposals for improvement.

After the diagnosis, the local economic actor is invited to engage himself to implement actions in order to strengthen the positive impacts and/or mitigate the negative impacts of the environment on his activity, and of his activity on the environment. This is the step 2 of the EIT Producer, the one of the Commitments. The technical team proposes a sheet which the producer chooses to use or not (see Figure 1).

The commitments can be made verbally as well as in writing, individually or collectively.

> "*It is essential that the producer personally determines his commitments, without being constrained by the technical team. The technical team is responsible for determining the modalities of support and follow-up with the producer. The deadlines set are determined according to the producer's possibilities and the project/program schedule*" (Approche Outil d'Intégration Environnemental-OIE Producteur/Productrice – version 5, page 18, doc. 32 – List of Document).

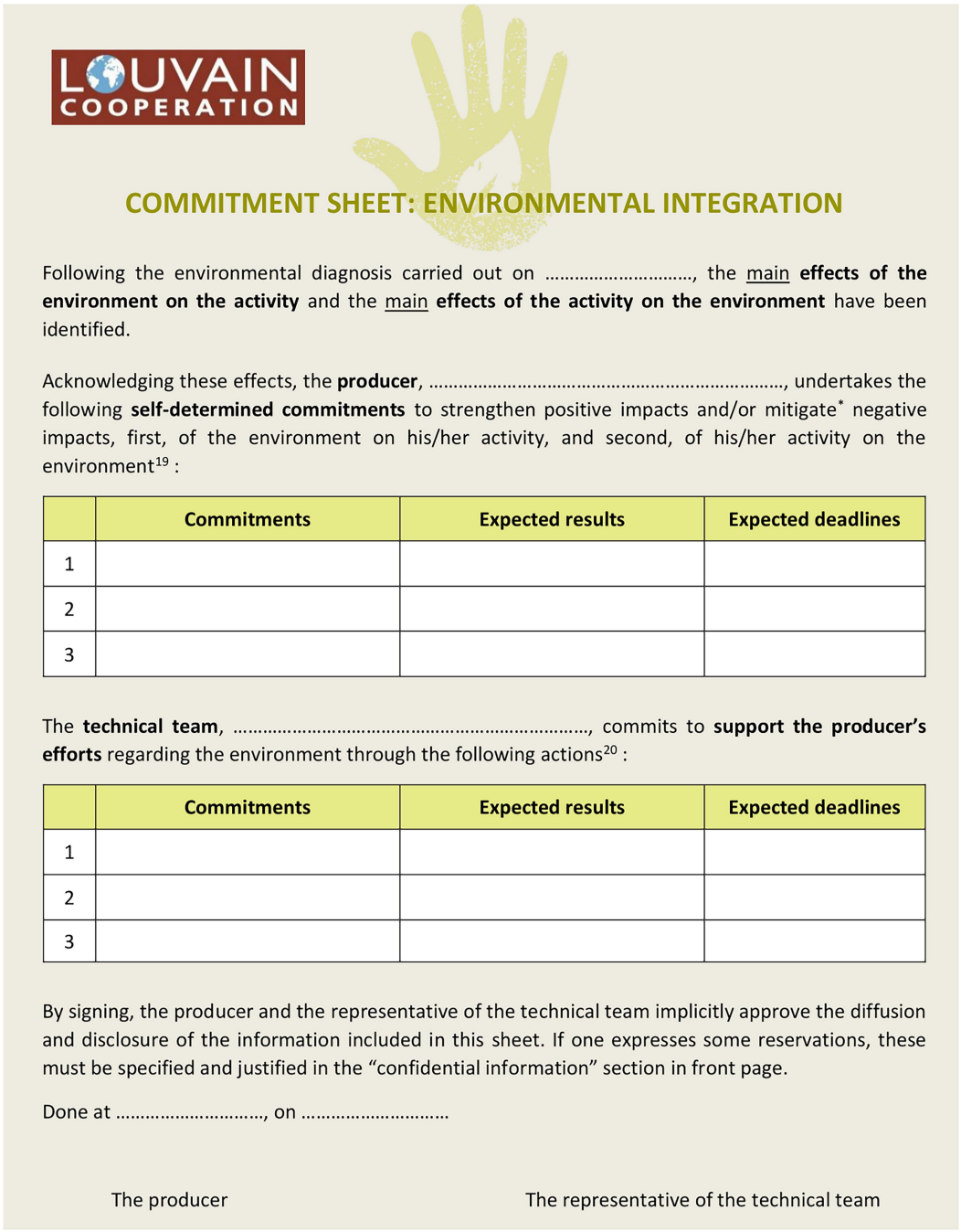
The third and final step of the EIT Producer is the Commitments Implementation. The actions resulting from the commitments are evaluated according to the deadlines determined during the commitment step. A new cycle of diagnosis and eventual new commitments may take place after some time, depending on the progress of the implementation of the actions.

Implementation process and impact of the EIT producer

The analyses on Axis 2 and Axis 3 were the basis for the results found about implementation process and impact of the EIT Producer. The material analyzed was extracted from:

1. Documents concerning the diffusion and appropriation process and impact of the EIT Approach,
2. Reports from the Food and Economic Security program and
3. Others.

In 2020, the EIT Approach had been disseminated across all of its ongoing projects up to that point. The EIT Approach was presented to all FES technical teams in the different countries where projects are implemented. Training sessions were organized, implemented using participatory methodologies and didactic materials with multiple information and practical examples. These teams actively participated in the improvement and adaptation of the EIT Approach according to the needs and circumstances inherent to each project and context where they were being implemented. By 2020, the EIT Approach was already part of the common vocabulary of all FES program projects. It was mentioned in all FES program Internal Reports in 2019 and in all Interim Evaluation Reports of Uni4Coop (the NGO Consortium of Francophone Belgian universities through which Louvain Cooperation is subsidized by DGD) projects carried out between 2018 and 2020. In most cases, it is presented as an intervention strategy, linked to the most important objectives and actions of the project and defined mainly as:



LOUVAIN COOPERATION

COMMITMENT SHEET: ENVIRONMENTAL INTEGRATION

Following the environmental diagnosis carried out on ……, the main **effects of the environment on the activity** and the main **effects of the activity on the environment** have been identified.

Acknowledging these effects, the **producer**, ……, undertakes the following **self-determined commitments** to strengthen positive impacts and/or mitigate* negative impacts, first, of the environment on his/her activity, and second, of his/her activity on the environment[19] :

	Commitments	Expected results	Expected deadlines
1			
2			
3			

The **technical team**, ……, commits to **support the producer's efforts** regarding the environment through the following actions[20] :

	Commitments	Expected results	Expected deadlines
1			
2			
3			

By signing, the producer and the representative of the technical team implicitly approve the diffusion and disclosure of the information included in this sheet. If one expresses some reservations, these must be specified and justified in the "confidential information" section in front page.

Done at ……, on ……

The producer

The representative of the technical team

FIGURE 1
The commitment sheet/EIT producer.

- A method of study/data collection/interview that allows the environment/environmental issues to be taken into account in the project and
- An approach that allows for self-determined commitments and actions by local economic actors regarding the environment.

Other definitions, less prominent in the reports, are:

- Training and exchange method between local technical teams and
- Awareness and empowerment of actors (partners, local economic actors) for environmental protection/ climate change

The implementation of EIT Approach took place through different actions, rhythms and intensities in each project,

according to their particularities and constraints. The application of its tools (EIT Program et EIT Producer) varied significantly within the projects. Figure 2 shows the geographical regions in which the EIT Approach was implemented within the FES program, the number of commitments made and the number of commitments implemented.

The EIT approach was not applied in all projects, but in those where it was, the number of EIT Producer applications was significantly higher than those of the EIT Program. The only exception was in Peru (where there were two EIT Programs and no EIT Producer). In this country there has been no implementation of the FES program since 2017, when the EIT Beneficial (now EIT Producer) was developed.

Under the Food and Economic Security Program/FES, the application of the 1015 EIT Producer resulted in 1049 self-determined commitments by the local producers. From this, 906 resulted on pro-environmental actions. Some examples of these actions can be seen in initiatives in Benin, such as crop rotation, composting and usage of organic inputs and pesticides, integrated management of crop pests and diseases, reforestation, the use of living hedges and many others. In this country, this application generated 794 pro-environmental actions, which represents 77.31% of the commitments. The application of the EIT-Producer in Togo generated 89 pro-environmental actions by economic agents, which corresponds to 82% of the total self-determined commitments undertaken by these actors.

The number of EIT Producer applications in each country varied significantly, as did the impact in terms of commitments (see Figure 2). In some, commitments were made, and this resulted in actions that were followed up by the technical teams. In others, the commitments steps were not register and/or followed up, which makes it impossible to know whether or not the commitments were made. These and other variations have characterized the implementation of the EIT Producerand its impacts, related to different reasons and particularities of each project. An example is illustrated in the excerpt from narrative report FES program AMSANA Benin (doc. 33 – List of Document):

> "*The decrease in the rate of implemented commitments compared to the previous year is due to the 400 new commitments made by the producers of the 3rd call* [call for participation in the FES program] *whose implementation will be effective next June* [a few months after the evaluation regarding this report]" (page 42,).

Evaluations of projects where the EIT Producer has been implemented emphasize the scale of its impacts.

> "(…) *It is important to note that the EIT, besides being an awareness tool, it is also an instrument for accountability and appropriation of mechanisms for an efficient and sustainable*

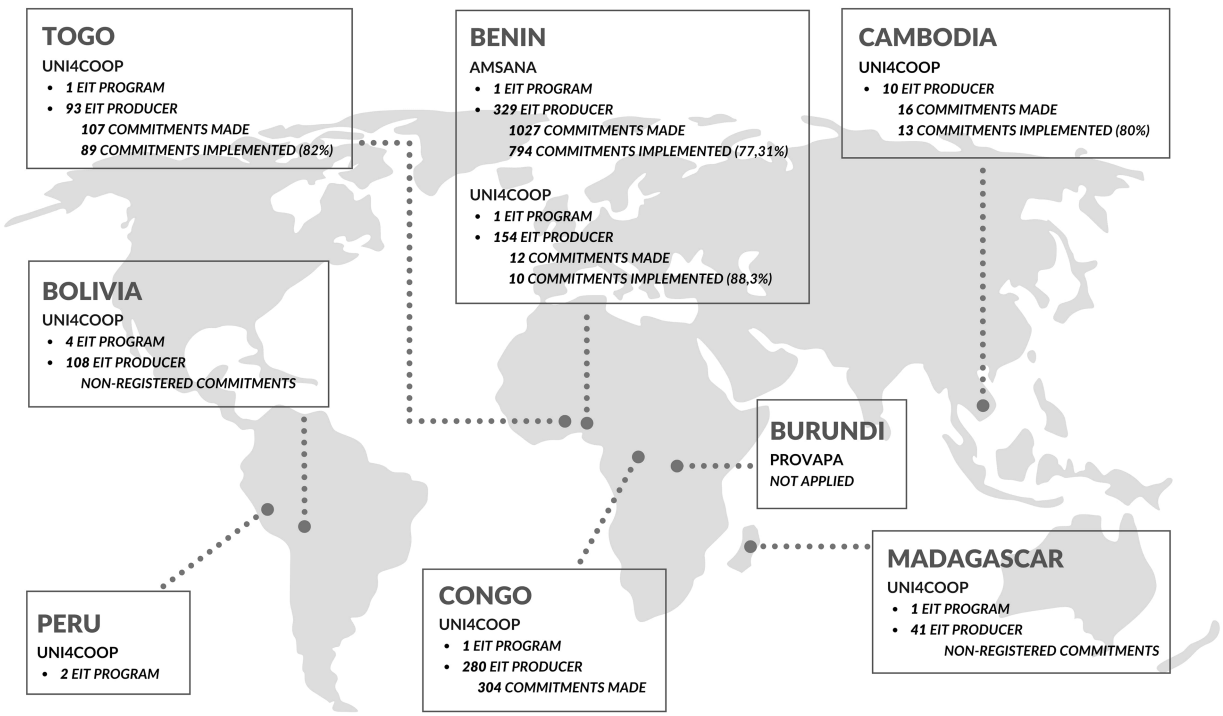


FIGURE 2
Implementation of the EIT approach in the FES program between 2016 and 2020.

> *environmental management.*" (internal project report FES program Uni4Coop Congo, p. 38, doc. 37 – List of Document).
>
> "*The implementation of the EIT Approach allows for diagnostic, commitment, monitoring, and evaluation actions in a few steps*" (mi-term evaluation report FES program Uni4Coop Bolivie, p. 64, doc. 35 – List of Document).

Regarding the difficulties and obstacles in the implementation of the EIT Producer, the excerpt from internal report FES program Uni4Coop Madagascar (doc. 38 – List of Document) exemplifies reasons attributed by the technical teams:

> "(…) *lack of time and personnel* (…) *difficulty in translating the concepts and terms of the tools into the official national language and local dialect*" (pages 14 and 53).

Discussion

The qualitative research on the construction, dissemination, appropriation and impact of the EIT Approach has made it possible to analyze an important and rich documentation. These documents testify to the trajectory and maturing of the rationalities that guide the participation of the Belgian NGO Louvain Coopération in international development cooperation. This is a plural material, with different structures, profile and objectives. They have been written by different people and groups, stakeholders of different hierarchical levels of the programs and projects of Louvain Coopération. They contain very pronounced nuances of language. This was crucial to the diversity of data and complexity of the analyses, both fundamental to the credibility of the research. All documents of the virtual library of Louvain Coopération concerning the EIT Approach were made available for the research, which greatly facilitated the research process. All documents that contained significant data on the research questions were selected, but overall, the data from the 46 selected documents did not saturate the questions. They provided highly relevant leads to answers to this research questions, and they also provided leads on the need for further research.

From the historical point of view of the EIT Producer (Axis 1 – building process), the commitments have been the element through which a conceptual, epistemological and political shift has occurred within Louvain Coopération initiatives regarding environmental integration. This led to a change of course, with a view to adopting a coherent approach and working in complementarity with other actors. This perspective is at the origin and basis of the current international development cooperation, endorsed and ratified in its most notorious documents. Louvain Coopération's impetus for building an environmental integration approach was to extend its functionality in the context of the objectives of its development cooperation programs. This integration should promote information and education. For whom? To the actors to whom its projects are mainly directed, local producers in peripheral and rural areas of the countries of the South. Why? To positively influence the awareness of its actors about the reciprocal effects between their production activities and the environment. And how to do this surmounting the risk that this integration is not exogenous, without meaning or appeal to these actors, pointed out by evaluators of cooperation programs in development? The main innovation of the EIT Approach version 2017, EIT Beneficial, brings an answer, that is, taking into account, seriously and concretely, the local actors. In this version, self-determined commitment is integrated into the EIT Approach Beneficial methodology.

That raising awareness of environmental protection is a very difficult task because it implies a change of mentalities and behaviors that are hegemonic and stimulated in the global consumer society, but also because in general it implies a personal engagement with a world that is not the one in which we live, but which is part of the future (Kempf, 2007; Moser, 2009; Bonnefoy et al., 2010; Girandola and Joule, 2012). The analysis of the documents of Axis 1 shows that the insertion of self-determined commitments has been the main strategy to achieve an approach of environmental integration capable of having a significant influence on the awareness of the actors and the whole psychological process that it implies. The EIT Producer is focused on the commitments of local producers. Self-determined commitments are clearly the main methodological dispositive of this variant. The proposed diagnosis (step 1 of the EIT Producer) aims at mobilizing the actors' intention to act. The topics/parts of the questionnaire used in the Environmental Diagnosis lets us presume its objective of promoting a rather broad and provocative reflection, including the survey of information about the producer's activities, the environmental context of these activities, the mutual effects between the environment and the producer's activity. The producer's willingness to engage with the environment, as well as his abilities and needs to do so, are also topics addressed in this step. In its final part, the focus is on the lessons learned from the diagnostics process. A set of topicals/parts that indicates that this step (Environmental Diagnosis) is conceived as a path leading to further, concerning these commitments, rather than as a moment with ends in itself.

People are not passive products of the circumstances of their lives (Bandura, 2006) and are able to determine and even change circumstances, within social and interpersonal contexts that are more or less supportive of this. The dialogical aspect that can be seen since the first versions of the EIT Approach is clearly reinforced in the EIT Producer application methodology. The interview procedure is, above all, a mark of the importance of an interpersonal environment in which the team provides

information and encourages a discussion that favors the producers' intention to act. The behavior change implies an intention to act that depends on convincing arguments about the benefits of change. Studies in various fields of application converge on this point (Nguyen, 2015; Saari et al., 2021 and others). The dialogical, collective interview is the main methodological tool of the EIT Producer. This interview frames an interpersonal relationship, in which the team is responsible for supporting the producers in their cognitive process to eliminate or significantly reduce their doubts and ambivalence about the change and the new behavior to adopt (Prochaska and DiClemente, 1992). Individuals make reasoned decisions (Ajzen, 1991). The methodological dynamics of applying steps 1 and 2 of the EIT Producer acts on the producers' decision-making process. It acts on the cognitive representation of these actors' willingness to adopt pro-environmental behavior (Ajzen, 1991) and favors their intention to act in favor of the environment by promoting social and interpersonal conditions that facilitate in them the psychological mechanism of predicting the consequences of these actions before deciding to take them and how easy or difficult it is to carry them out.

The application of the 1015 EIT Producer resulted in 1049 self-determined commitments by the local producers, made of intentions to act (e.g., plant trees around river areas, eliminate the use of plastics in the packaging process, reduce the use of chemical pesticide and many others) eventually listed and signed by the producers (registered in the commitments sheet form). The intention to act is the direct antecedent of behavior and the stronger the intention, the more effort an individual will make to adopt pro-environmental behavior (Ajzen, 1991; Steg and Nordlund, 2013). The procedure of listing the desired actions and taking the commitment to implement them can be considered as a methodological tool of the EIT Producer that operates in reinforcing the producers' intention to act and thus increases the likelihood that they will actually implement them. Intention is an important predictor of people's ecological behavior (Steg and Nordlund, 2013). Self-commitment prompts the EIT Producer to positively impact the adoption of pro-environmental behaviors and the 906 implemented actions (from the total of 1046 commitments) corroborate that. The non-mandatory use of the commitment form is a norm with the EIT Approach, in line with the principle of "openness" and the autonomy of the actors, which is the basis of the approach, defended in all of its versions. This aspect, however, does not favor the quantitative analysis of its impacts. A multi-method qualitative perspective on data collection combined with quantitative methods would be very beneficial for further research.

Conclusion

The Document Analysis on EIT Approach shows that self-determined commitment is the nodal strategy of the EIT Producer, and that it primarily aims to affect the intention of local producers to act. The results indicate that the self-determined commitments undertaken by local economic agents is a factor that promotes the adoption of pro-environmental behavior. This is in line with theories and studies that assume intention as an internal variable that influences people's environmental behavior patterns (Ajzen, 1991, 2011; Prochaska and DiClemente, 1992; Farrow et al., 2017; Iman et al., 2019; Schill et al., 2019). The EIT Producer encourages self-determined commitments by local economic agents, representing a crucial methodological aspect for generating pro-environmental behavior.

North–South development cooperation is a complex institution and involves an immense multiplicity of actors. Its foundations and priorities are not at all convergent, and the sectors in which it intervenes are increasingly dispersed, affecting very different scales (Étienne, 2007). Its challenges are enormous and multidimensional, but in all sectors and scales it is necessary to change both the ideas and the practices of the actors (European Commission, 2011). The EIT Approach, especially through its EIT Producer variant, constitutes a relevant methodology for projects committed to sustainable development.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

VH and PU contributed to the conception and design of the study, organized the database, and wrote sections of the manuscript, contributed to the manuscript revision, read, and approved the submitted version. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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A one-hour walk in nature reduces amygdala activity in women, but not in men

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Urban dwellers are more likely to develop mental disorders such as mood and anxiety disorder as well as schizophrenia compared to rural dwellers. Moreover, it has been demonstrated that even short-term exposure to nature can improve mood and decrease stress, but the underlying neural mechanisms are currently under investigation. In the present intervention study we examined the effects of a one-hour walk in an urban vs. natural environment on activity in the amygdala, a brain region previously associated with stress processing. Before and after the walk 63 participants underwent an fMRI paradigm inducing social stress. Since there is a pronounced gap in the literature regarding interindividual differences in stress-related neural effects of urban and natural environments, we set out to explore sex differences. We observed that amygdala activity decreased after the walk in nature, but only in women, suggesting that women may profit more from salutogenic effects of nature. Moreover, performance on the arithmetic tasks improved in women after the walk in nature, whereas men performed better after the walk in the urban environment. To our knowledge, this is the first study to report differencial tendencies in men and women concerning the stress-related neural activity as an effect of acute exposure to urban vs. natural environments. Furthermore, our findings highlight the importance of sex differences when exploring effects of the environment on brain function and stress. Evidence for beneficial effects of nature on stress-related brain regions may inform urban design policies to focus on providing more accessible green areas in cities and this study suggests that sex differences in experiencing the environment should be taken into consideration.

KEYWORDS

environment, nature, urban, sex, brain, amygdala, stress

Introduction

Although living in an urban environment may have benefits, such as accessibility to education, social services, and amenities (Cohen, 2006), it is likewise linked to increased levels of mental disorders such as mood and anxiety disorders, depression and schizophrenia (Peen et al., 2007). Moreover, it has been repeatedly shown that short visits

to nature can be beneficial to cognition and mental health. A growing body of empirical research has demonstrated affective (White et al., 2013; Berto, 2014; Barnes et al., 2019) and cognitive benefits of nature exposure (Berman et al., 2008; Ohly et al., 2016; Stevenson et al., 2018).

The pathways and mechanisms by which nature influences psychological well-being are still unclear. The biophilia hypothesis (Wilson, 1984) states that humans feel an innate affection towards all living beings and that this attitude is rooted in our evolutionary past. Based on this account, Attention Restoration Theory (ART) (Kaplan and Kaplan, 1989) proposes that exposure to natural environments restores voluntary attention. Since nature is filled with intrinsically fascinating stimuli (e.g., trees, lakes), it evokes involuntary attention, allowing voluntary attentional processes to recover. Therefore, after exposure to a natural environment, abilities that depend on voluntary attentional mechanisms, such as working memory, should improve (Berman et al., 2008). In accordance with ART, it has been shown that short-term exposure to nature can restore directed attention and improve cognitive capacity (Berman et al., 2008; Ohly et al., 2016; Stevenson et al., 2018). In contrast, Stress Reduction Theory (SRT) (Ulrich et al., 1991) posits that features found in nature such as vegetation, complexity and absence of threat evoke affective responses that lead to restorative processes. In line with SRT, several studies have demonstrated that exposure to natural environments can improve mood (Berman et al., 2008; Hartig et al., 2014; McMahan and Estes, 2015) and have beneficial effects on stress (Oh et al., 2017; Tost et al., 2019). These results are also supported in studies with physiological indicators of stress, showing that heart rate, blood pressure, and cortisol levels decreased after exposure to natural compared to the urban environments (Park et al., 2010; Lee et al., 2011; Mao et al., 2012; Ochiai et al., 2015; Lanki et al., 2017; Ewert and Chang, 2018).

However, the neural mechanisms behind the effects of nature and urban exposure on stress remain largely unstudied. In cross-sectional studies, a positive association was shown between forest coverage around older adults' home and amygdala integrity (Kühn et al., 2017), as well as lower amygdala activity during social stress in rural compared to urban dwellers (Lederbogen et al., 2011), indicating that nature in the neighborhood may have salutogenic effects on the amygdala. On the other hand, research investigating the brain-related effects of short-term exposure to natural vs. urban environment has focused on rumination. A study in which participants went on a 90-min walk in an urban vs. a natural environment showed that self-reported rumination as well as activity in the subgenual prefrontal cortex (sgPFC), associated with rumination, decreased only after the walk in nature, suggesting that exposure to nature may be beneficial in reducing rumination and activity in its neural correlates (Bratman et al., 2015).

To examine the causal effects of acute exposure to natural and urban environments on stress-related neural mechanisms, we conducted a functional magnetic resonance imaging (fMRI) intervention study, measuring a change in stress-related brain regions after a one-hour walk in an urban vs. a natural environment. We observed that during the Fearful Faces Task (FFT), activity in the amygdala, a stress-related brain region, decreased after the walk in nature, whereas it remained stable after the walk in an urban environment, indicating that acute exposure to nature may have salutogenic effects on stress-related brain regions (Sudimac et al., 2022).

Social stress (Lederbogen et al., 2013), experiences due to overcrowding (Kennedy et al., 2009), and lack of green areas in cities (Van den Berg et al., 2010) have been proposed as potential causes of disadvantageous effects of urban environments on mental health. Thus, it has been suggested that spending time in green spaces can attenuate social stress present in urban dwellers (Ulrich et al., 1991). In order to examine the neural mechanism underlying social stress after a walk in a natural vs. urban environment, we employed the Montreal Imaging Stress Task (MIST), a paradigm designed to induce social stress. Comparable to the results of the FFT, a differential effect of environment was observed in the MIST, showing that amygdala activity descriptively decreased during the social stress task only after the walk in nature, suggesting that a one-hour exposure to nature was beneficial for amygdala activity during social stress (Sudimac et al., 2022).

However, little is known about the role of interindividual differences in experiencing urban and natural environments, such as sex. It has been previously shown that women are more connected to nature (Zhang et al., 2014; Dean et al., 2018; Rosa et al., 2020) and appreciate nature's beauty more than men (Zhang et al., 2014). Studies with children have also shown that girls display stronger emotional affinity toward nature than boys (Bagot and Gullone, 2003; Larson et al., 2010). Furthermore, it has been reported that women are more eco-friendly and more concerned about the environment than men (Zelezny et al., 2000). Women consume less carbon and purchase more green products (Zhao et al., 2021) and, as reported in a cross-national study, they show pro-environmental behavior more frequently than men (Hunter et al., 2004). Sex differences were likewise observed in the relation between urban upbringing and brain structure. Namely, gray matter volume in perigenual anterior cingulate cortex (pACC), a key region for regulation of amygdala activity (Pezawas et al., 2005) previously related with urbanicity and stress (Lederbogen et al., 2011), was negatively correlated with years spent in a city during childhood, but only in men (Haddad et al., 2015).

Since sex differences were reported in connectedness to nature (Zhang et al., 2014; Dean et al., 2018; Rosa et al., 2020) and in the association between urban upbringing and gray matter volume (Haddad et al., 2015), in this paper we aimed to explore potential sex differences in amygdala activity change after the walk in the natural vs. urban environment.

Based on the aforementioned literature, we predicted that the walk in nature would have a more beneficial effect for amygdala activity in women compared to men. Furthermore, based on the previous studies showing that exposure to nature is beneficial for

attention and cognitive capacity (Berman et al., 2008; Ohly et al., 2016; Stevenson et al., 2018), and taking into account the importance of exploring interindividual differences such as sex when investigating the effects of man-made environments on cognition (Tawil et al., 2021), we predicted that cognitive performance on the MIST would improve after the nature compared to the urban walk and examined potential sex differences.

Materials and methods

Participants

The sample consisted of 63 participants (29 females, total mean age = 27.21 years, *SD* = 6.61, age-range = 18–47 years). The participants were pseudo-randomly assigned either to a nature (32 participants) or an urban walk (31 participants), while controlling for equal distribution of men and women. Participants' age, occupation, education, income and percentage of participants brought up in a city did not significantly differ between the two groups. An overview over the control variables in the two conditions and details about participant recruitment were previously reported elsewhere (Sudimac et al., 2022). Participants were told that they would take part in a magnetic resonance imaging (MRI) study in which they would go for a walk, but were not informed about the research question of the study. All participants were fluent in German, right-handed, and were not diagnosed with any psychological or neurological disorder.

The study was approved by the Local Psychological Ethical Committee at the Center for Psychosocial Medicine at University Medical Center Hamburg-Eppendorf in Hamburg, Germany (LPEK-0054). We obtained written informed consent from all participants and they received monetary compensation.

Study procedure

The experiment was conducted in late summer/fall 2019 between 10:00 a.m. and 5:00 p.m. The flowchart of the study procedure is shown on Figure 1. Upon arrival, participants signed the informed consent, filled out the questionnaires and performed a working memory task. Subsequently, the participants underwent an fMRI scanning procedure that included a resting state sequence with questions on rumination (Kühn et al., 2013), the MIST (Dedovic et al., 2005) and the FFT (Mattavelli et al., 2014). After the scanning session, participants were randomly assigned to a 60-min walk in either a natural (Figure 2, left) or urban environment (Figure 2, right). Even though the definition and also the dichotomy of 'natural' and 'urban' environment has been a subject of debate (Karmanov and Hamel, 2008), the 'natural environment' we refer to is an urban forest, the largest green area in the city of Berlin (Grunewald forest; Figure 2, left), whereas 'urban environment' refers to a busy street in one of the city centers in Berlin with shopping malls (Schloßstraße; Figure 2, right). As recommended in a recent review (Barnes et al., 2019), we previously reported the exact locations of the walk and the characteristics of the urban and natural environments (Sudimac et al., 2022).

The participants were shown the walk on a map (straight path) and subsequently they were picked up at the lab and brought by taxi to the starting point of the walk. They carried a mobile phone that logged their global positioning system (GPS) data during the walk, to ensure that they walked the intended route. Participants went on the walk alone and were instructed not to enter shops or use their mobile phones, to avoid potential distraction. They were given a bagged lunch that they could eat during the walk. After 30 min, an alarm signal went off on the phone, and participants were instructed to turn around and continued the walk back to the starting point. Here they were picked up by a taxi and brought back to the lab.

After the walk the same fMRI scanning procedure was repeated, with one additional stress-inducing task, the Social-Evaluative Threat task (SET; Wager et al., 2009), a modified version of the Trier Social Stress Test (TSST; Kirschbaum et al., 1993), also meant to induce social stress and administered only after the walk at the end of the MRI session, since we reasoned the cover story would not have been credible twice. Finally, participants filled out the questionnaires and were debriefed and informed about the aim of the study.

Functional imaging paradigm

The order of the MIST and the FFT was counterbalanced between participants, but their respective order was the same for each participant at pretest and posttest. The tasks were presented via a projector and mirror system and the participants answered using an MR-compatible response box.

Montreal Imaging Stress Task

The Montreal Imaging Stress Task (MIST; Dedovic et al., 2005) is a computerized fMRI-adapted paradigm, based on the TSST (Kirschbaum et al., 1993) and was administered in order to induce social stress, since the SRT hypothesizes that nature's restorative potential is most evident when the individual is stressed (Ulrich et al., 1991). In the MIST participants solve mental arithmetic tasks with a difficulty and time limit designed to be just beyond participant's cognitive capacities. The MIST consisted of three different conditions: Experimental, Control, and Rest.

In the beginning of the task there was a training session in which the participant's ability to perform mental arithmetic was evaluated, without a time limit or progress bar, to calibrate for a default time limit in the Experimental condition. In the Experimental condition the information about individual performance and a fake-average performance of all participants was presented after each response with arrows on a bar above the arithmetic tasks (Figure 3, above left). This fake-average performance was consistently considerably better than the individual's performance in order to enhance social stress. In the

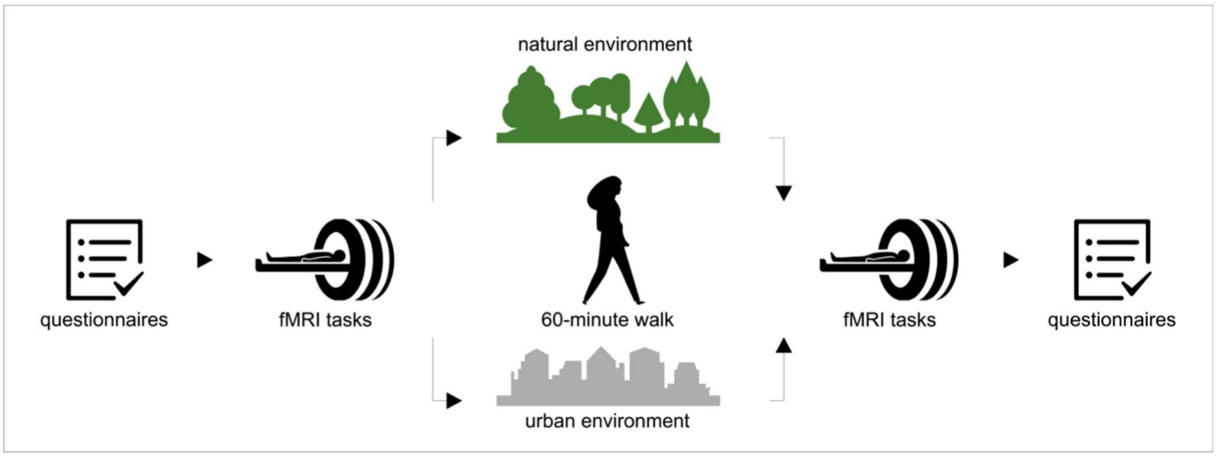

FIGURE 1
Flowchart of the study procedure. Upon arrival participants filled out the questionnaires and then underwent the fMRI scanning procedure, consisting of Montreal Imaging Stress Task (MIST) and Fearful Faces Task (FFT). Subsequently, participants were randomly assigned to go either for a 60-min walk in either a natural or an un urban environment. After the walk participants again underwent the fMRI procedure and at the end they filled out the questionnaires.

FIGURE 2
Location of the nature and urban walk. Left: Sample picture of the route in the natural environment in Grunewald forest, the largest green area in the city of Berlin. Right: Sample picture of the walk in the urban environment Schloßstraße, a busy shopping area with traffic in Berlin.

Experimental condition, the MIST program reduced the time limit to 10% less than the participants's average time after three correctly solved tasks. Conversely, if the participants responded on three consecutive tasks incorrectly, the program increased the time limit for the following tasks by 10%. This staircase procedure in the Experimental condition lead to a range of about 20 to 45% of correct answers (Dedovic et al., 2005). The mathematical arithmetic tasks were designed so that only one digit between 0 and 9 was the correct response. In order to respond, participants selected a digit on the rotary dial from 0 to 9 by pressing the left or the right button on the button box to highlight the neighboring left or right number until they reached the number they intended to respond; in that case the middle button was used to confirm the answer. The participant's answer was compared with the correct answer for the arithmetic task and the feedback "Correct" or "Incorrect" was shown in the feedback field. If the time for the arithmetic task ran out, the feedback "Time out" was displayed (Dedovic et al., 2005).

In the Control condition the mental arithmetic tasks had the same level of difficulty as in the Experimental condition, but the participant's performance as well as the fake-average performance of all participants was not displayed and there was no time limit for solving the task (Figure 3, above right). The feedback for each task was also displayed, but since there was no time limit, average correct performance in the Control condition is around 90% (Dedovic et al., 2005).

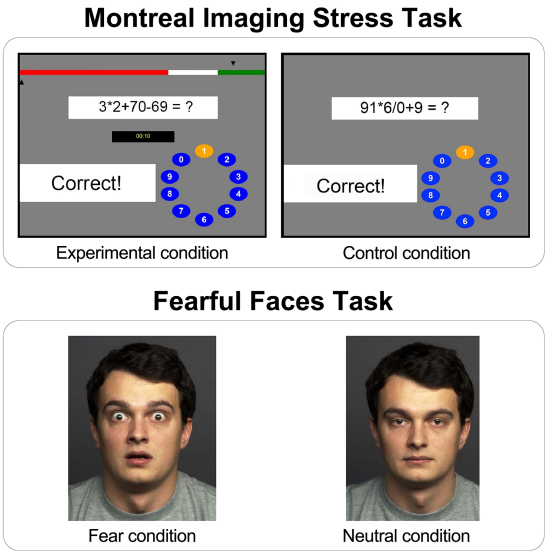

FIGURE 3
Graphical user interface of the Montreal Imaging Stress Task (MIST) and the Fearful Faces Task (FFT). Above left: Experimental condition within the MIST with a bar presenting participant's performance (bottom arrow) and fake-average performance (top arrow), the mental arithmetic task, the field showing remaining time for the task, the feedback field and the rotary dial for the response submission; Above right: Control condition within the MIST with the mental arithmetic task, the feedback field and rotary dial; Below left: Example fearful facial expression stimulus within the FFT (Fear condition); Below right: Example neutral facial expression stimulus within the FFT (Neutral condition).

In the Rest condition, treated as a baseline, the participants saw the rotary dial and empty fields for arithmetic tasks and the feedback, but no task was displayed and the participants were asked to simply look at the screen (Dedovic et al., 2005).

Fearful Faces Task

An adapted version of the Fearful Faces Task (FFT; Mattavelli et al., 2014) was used, designed to measure amygdala activity during fearful and neutral facial expressions. While in the MRI scanner, participants were presented with stimuli consisting of 15 male and 15 female faces, each depicting fearful (Fear condition; Figure 3, below left) or neutral facial expression (Neutral condition; Figure 3, below right). Both fearful and neutral facial expressions were shown either for 1,000 ms (unmasked stimuli) or for 17 ms, followed by a mask with neutral facial expressions presented for 983 ms (masked stimuli), since the amygdala has been shown to respond to masked stimuli even when most of the participants were not aware of their presence (Ohman et al., 2007; Kim et al., 2010; Brooks et al., 2012).

We used the set of 60 stimuli from the FACES database by the Max Planck Institute for Human Development in Berlin (Holland et al., 2019), consisting of face photographs on a gray background, matched on size and luminance. The fMRI paradigm consisted of 22 blocks with 6 pictures interleaved with a 200 ms break between pictures. Each block was followed by a white fixation cross presented for 9 s. In order to monitor the participants' attention, the fixation cross was red on two occasions and participants were instructed to press the button on the response box as soon as they would saw the red cross on the screen. The order of the stimuli was randomized within 10 versions of the FFT, and the task version was introduced in the fMRI data analysis as a covariate. The whole task sequence lasted 8 min and 28 s. The task was presented via a projector and mirror system and the participants answered using the response box. The FFT was presented using the software Presentation (version: 19.0).

Behavioural data

Performance on the Montreal Imaging Stress Task

Performance on the MIST was defined as the percentage of correct answers and mean reaction time (RT) necessary to solve the mental arithmetic tasks in the Experimental condition, during social stress. The percentage of correct answers was analyzed with a two-way ANOVA with environment as a between-subject factor (urban vs. natural) and time as a within-subject factor (before vs. after the walk) using the ezANOVA function from the R package ez (Lawrence and Lawrence, 2016). The same analysis was performed separately within subsamples of women and men. Since the Shapiro–Wilk normality test indicated that female and male subsamples were not normally distributed, we analyzed the percentage of correct answers within each of the subsamples with robust ANOVA using the R package WRS2 (Mair and Wilcox, 2020).

In the RT analysis two participants had a RT that was more than 2.5 SD higher than the mean, therefore they were treated as outliers and excluded from further analysis. The RT was as well analyzed with a two-way ANOVA with environment as a between-subject factor (urban vs. natural) and time as a within-subject factor (before vs. after the walk). Since the RT was not normally distributed across the sample nor across the male subsample, the RT analysis was also performed with robust ANOVA using the R package WRS2 (Mair and Wilcox, 2020). The RT in the female subsample was analyzed with ANOVA using the R package ez (Lawrence and Lawrence, 2016).

Post-hoc t-tests were subsequently conducted for both the percentage of correct answers and the RT in order to examine if there were changes in performance after the walk in the urban and in the natural environment within each of the subsamples.

Questionnaires

Behavioural measures included questionnaires assessing mood [German version of Positive and Negative Affect Schedule, PANAS (Krohne et al., 1996)], perceived stress during the previous hour [adapted German version of Perceived Stress Scale, PSS (Klein et al., 2016)], rumination during the previous hour [adapted Rumination subscale from German version of Rumination Reflection Questionnaire, RRQ (Elkhaouda, 2010)],

and perceived restorativeness [German version of Perceived Restorativeness Scale, PRS (Schönbauer, 2013)], in addition to a computerized Digit Span Backwards (DSB) task, which assesses working memory (Berman et al., 2008).

All behavioural measures were administered before and after the walk, except for the PRS which assesses the perceived restorativeness of an environment and was therefore only administered after the walk. Additionally, participants filled out a sociodemographic questionnaire, reported on the weather during the walk and the overall pleasantness of the walk, and responded to a German version of the Connectedness to Nature questionnaire (Cervinka et al., 2009). The results of the analysis of this data as well as of the physiological data (electrodermal activity and heart rate) were previously reported (Sudimac et al., 2022).

Magnetic resonance imaging

Data acquisition

All images were acquired on a Siemens Tim Trio 3 T scanner (Erlangen, Germany) using a 32-channel head coil. The T1-weighted images were obtained using a three-dimensional T1-weighted magnetization prepared gradient-echo sequence (MPRAGE; repetition time (TR) = 2,500 ms; echo time (TE) = 4.77 ms; TI = 1,100 ms, acquisition matrix = 256 × 256 × 192, flip angle = 7°; 1x1x1 mm^3 voxel size). Whole brain functional images were collected using a T2*-weighted echo-planar imaging (EPI) sequence sensitive to BOLD contrast (TR = 2000 ms, TE = 30 ms, acquisition matrix = 216 × 216 × 129, flip angle = 80°, slice thickness = 3.0 mm, distance factor = 20%, FOV = 216 mm, 3 × 3 × 3 mm^3 voxel size, 36 axial slices, using GRAPPA).

Data preprocessing

Functional imaging data were preprocessed and analyzed using Statistical Parametric Mapping software (SPM12[1]). EPIs were corrected for slice timing and head motion and transformed into the stereotactic normalized standard space of the Montreal Neuroimaging Institute (MNI) using the unified segmentation algorithm. Finally, spatial smoothing with a 6-mm full width at half-maximum (FWHM) Gaussian kernel was performed. The voxel size was not changed during preprocessing but kept in the original acquisition dimension (3 × 3 × 3 mm^3).

Data analysis

Montreal Imaging Stress Task

At the first level analysis estimates of functional activation during conditions (Experimental, Control and Rest) were obtained using a blocked analysis. A high-pass filter (cut-off 520 s) was applied. We then used an approach based on our region of interest (ROI), bilateral amygdala. The bilateral amygdala mask was derived from the Automated Anatomic Labelling atlas 2 (Rolls et al., 2015) and had a volume of 3,744 mm^3.

We extracted the beta values for each of the contrasts (Experimental > Rest and Control > Rest) within the bilateral amygdala, using the marsbar toolbox [version 0.44 (Brett et al., 2002)]. As previously reported, we observed a significant interaction in the MIST between environment and time in amygdala pooled activity of the Experimental and Control condition, which descriptively decreased after the walk in nature and remained stable after the walk in the urban environment (Sudimac et al., 2022). In the present study we examined the change in amygdala activity in the MIST in male and female subsample separately. In both subsamples a two-way ANOVA was conducted with environment as a between-subject factor (urban vs. natural) and time as a within-subject factor (before vs. after the walk) in amygdala pooled activity of Experimental and Control condition. Subsequently, two-tailed *post-hoc* *t*-tests were conducted in order to examine if the environment-by-time interaction was driven by a change in amygdala activity after the walk in the urban or in the natural environment.

Fearful Faces Task

At the first level analysis of the FFT, estimates of functional activation during each condition (unmasked Fear, unmasked Neutral, masked Fear, masked Neutral, Response) were modelled using an event-related paradigm. A high-pass filter (cut-off 128 s) was applied and the ROI-based approach was used, focusing on the bilateral amygdala.

We reasoned that the intervention, namely a one-hour walk, would globally affect the stress levels and therewith stress-related brain activity, not only when contrasting the Fear > Neutral condition. Therefore, we examined amygdala activity in the Fear and in the Neutral condition separately, by extracting the blood-oxygen-level dependent (BOLD) signal within the bilateral amygdala using the marsbar toolbox [version 0.44 (Brett et al., 2002)]. We averaged data from unmasked and masked stimuli, because the results were similar.

Within both the male and female subsamples we conducted a two-way ANOVA with environment as a between-subject factor (urban vs. natural) and time as a within-subject factor (before vs. after the walk) in amygdala activity pooled from the Fear and Neutral conditions. Two-tailed *post-hoc* *t*-tests were performed within the urban and the natural environment to examine if the environment-by-time interaction was driven by a change in amygdala activity after the urban walk or the walk in nature.

Results

In the MIST, as hypothesized, we observed a significant environment-by-time interaction in the female subsample in pooled amygdala activity from the Experimental and Control conditions [$(F(27) = 4.74,\ p = 0.038,\ \eta^2_g = 0.04)$; Figure 4]. The interaction was driven by amygdala activity which descriptively

1 https://www.fil.ion.ucl.ac.uk/spm/software/spm12/

decreased after the walk in nature [$t(14) = 1.89$, $p = 0.080$], whereas it remained stable after the walk in the urban environment [$t(13) = -1.15$, $p = 0.270$; Supplementary Tables 1, 2]. Furthermore, the environment-by-time interaction in the female subsample was driven by a decrease in amygdala activity in the Experimental condition after the walk in nature [($t(14) = 2.35$, $p = 0.034$); Figure 4, left] and by an increase in activation in the Control condition after the walk in the urban environment [($t(13) = -2.62$, $p = 0.021$); Figure 4, right]. In the male subsample, however, there was no significant environment-by-time interaction in amygdala activity [($F(32) = 1.28$, $p = 0.266$, $\eta^2_g = 0.008$); Supplementary Figure 1] and it remained stable after both the walk in the natural [($t(16) = 0.93$, $p = 0.367$)] and the urban environment [($t(16) = -0.66$, $p = 0.516$); Supplementary Tables 1, 2].

In the FFT we observed a significant environment-by-time interaction in the male subsample [$F(32) = 4.37$, $p = 0.045$, $\eta^2_g = 0.05$; Supplementary Figure 2], driven by an increase in amygdala activity after the walk in the urban environment [($t(16) = -1.99$, $p = 0.063$)], while there was no significant interaction in the female subsample [$F(27) = 1.71$, $p = 0.203$, $\eta^2_g = 0.02$]. However, in line with the results on the MIST, amygdala activity after the walk in nature significantly decreased in women [($t(14) = 2.89$, $p = 0.012$); Figure 5], whereas it remained stable in men [($t(16) = 1.06$, $p = 0.303$); Supplementary Tables 1, 2].

Exploratorily, we examined the relationship between the change in amygdala activity after the walk and connectedness to nature score. We observed a positive correlation between the change in amygdala activity on the MIST after the urban walk in women and their connectedness to nature [$r(12) = 0.55$, $p = 0.043$; Supplementary Figure 3], whereas no correlation was found in men [$r(15) = 0.12$, $p = 0.641$].

Regarding the participants' cognitive performance, defined as percentage of correct answers and mean RT in the Experimental condition in the MIST, we observed no significant environment-by-time interaction neither on the whole sample (Supplementary Table 3), nor when splitting the sample into males and females (Supplementary Table 4). Interestingly, the results revealed that men had a higher percentage of correct answers in the Experimental condition in the MIST [$t(54.5) = -2.18$, $p = 0.034$], compared to women.

Post-hoc t-test showed that the percentage of correct answers in the Experimental condition decreased in women after both the urban [$t(13) = 3.03$, $p = 0.010$] and nature walk [$t(14) = 2.68$, $p = 0.019$], as well as in men after the walk in nature [$t(16) = 2.63$,

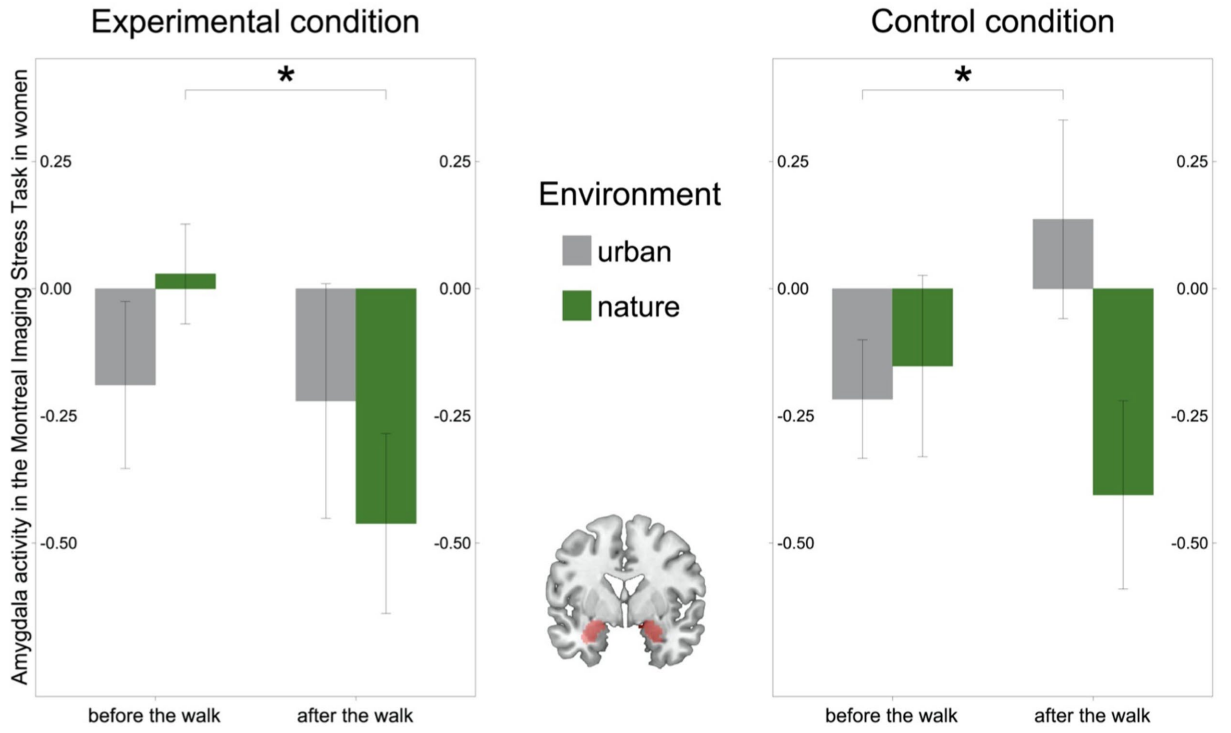

FIGURE 4
Amygdala activity in the Montreal Imaging Stress Task (MIST) in women. Left: Amygdala activity (beta values) in the Experimental condition in the MIST decreased after the walk in the natural environment in women. Right: Amygdala activity (beta values) in the Control condition in the MIST increased after the walk in the urban environment in women. Middle: Region of interest, the bilateral amygdala as defined in Automated Anatomic Labelling Atlas 2. Significant differences are indicated with asterisks (*p<0.05); error bars represent one standard error of the mean.

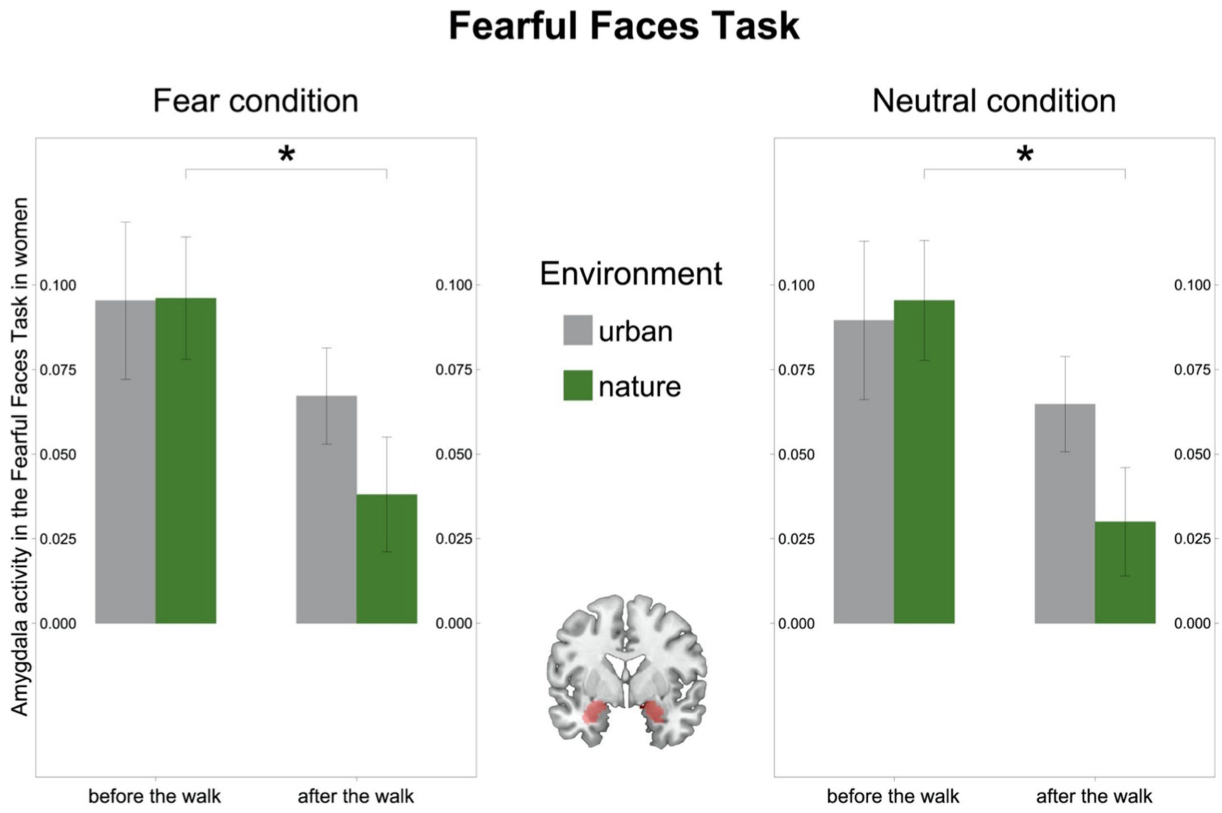

FIGURE 5
Amygdala activity in the Fearful Faces Task (FFT) in women. Left: Amygdala activity (BOLD signal) in the Fear condition in the FFT decreased after the walk in the natural environment in women. Right: Amygdala activity (BOLD signal) in the Neutral condition in the FFT decreased after the walk in the natural environment in women. Middle: Region of interest, the bilateral amygdala as defined in Automated Anatomic Labelling Atlas 2. Significant differences are indicated with asterisks (*p<0.05); error bars represent one standard error of the mean.

$p = 0.018$], whereas the percentage of correct answers in men did not change after the walk in the urban environment [$t(16) = 1.51$, $p = 0.151$].

However, the mean RT necessary to solve mental arithmetic tasks in the Experimental condition decreased in women only after the walk in nature [$t(13) = 2.60$, $p = 0.022$] and in men only after the walk in the urban environment [$t(16) = 3.14$, $p = 0.006$; Figure 6; Supplementary Table 5]. On the other hand, the RT did not significantly change for women after the walk in the urban environment [$t(13) = 1.96$, $p = 0.072$] nor for men after the walk in the natural environment [$t(15) = 1.76$, $p = 0.099$; Figure 6; Supplementary Table 5].

Discussion

In order to investigate the causal effects of the environment on stress-related brain regions, we conducted an fMRI intervention study in which a change in the amygdala was measured as an effect of a one-hour walk in an urban vs. natural environment. We have previously shown that activity in the amygdala decreased as the result of a one-hour walk in nature, whereas it remained stable after a walk in the urban environment while participants underwent the FFT. Consistent with this finding, a significant environment-by-time interaction during the MIST indicated that amygdala acvitivity descriptively decreased as well on the social stress task after the walk in the natural environment, whereas it remained stable after the walk in the urban environment, suggesting salutogenic effects of nature exposure on the amygdala (Sudimac et al., 2022).

However, there is a pronounced gap in the literature regarding the role of interindividual differences in the effect of exposure to urban and natural environments on brain regions related to social stress. Since sex differences have been previously reported in connectedness to nature (Zhang et al., 2014; Dean et al., 2018; Rosa et al., 2020), as well as in the association between urban upbringing and gray matter volume (Haddad et al., 2015), here we set out to explore sex differences in amygdala activity change as an effect of the urban vs. nature walk.

In line with our hypothesis, in the MIST in the female subsample we observed an interaction between environment and time, showing that amygdala activity during the MIST descriptively decreased after the walk in the natural environment, whereas it remained stable after the walk in the urban environment. On the other hand, the amygdala activity during the MIST in the male subsample did not significantly change after

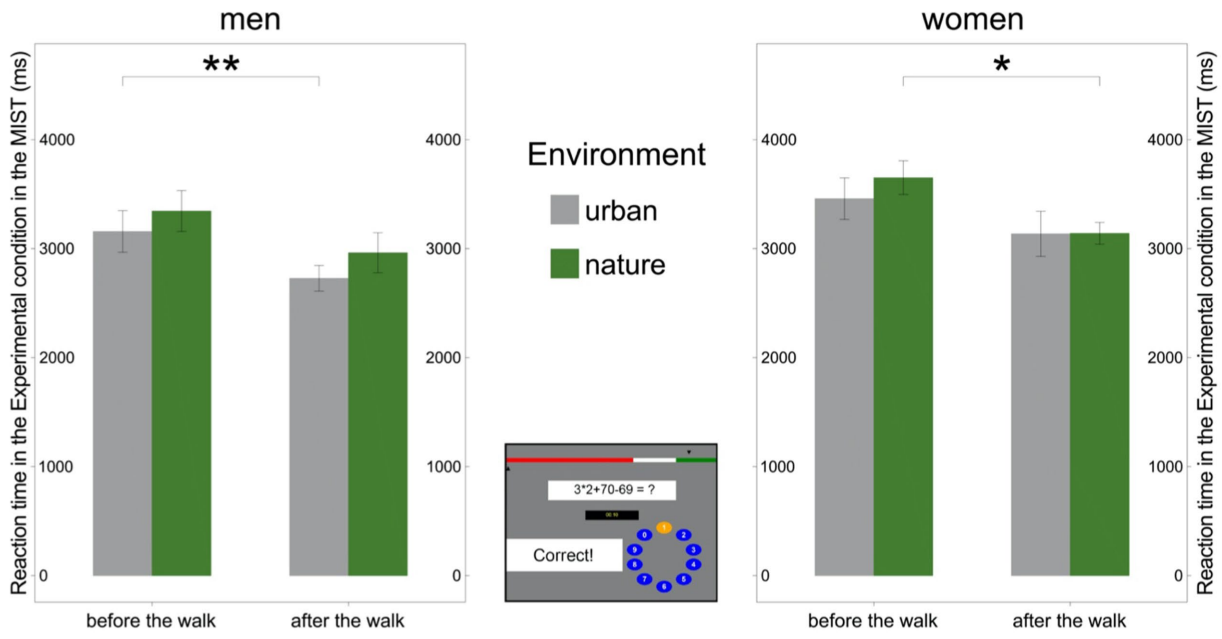

FIGURE 6
Reaction time in the Experimental condition of the Montreal Imaging Stress Task (MIST) by sex. Left: Reaction time in the Experimental condition of the MIST decreased after the walk in the urban environment in men. Right: Reaction time in the Experimental condition in the MIST decreased after the walk in the natural environment in women. Middle: Experimental condition in the MIST. Significant differences are indicated with asterisks (*p<0.05; **p<0.01); error bars represent one standard error of the mean.

both the walk in the urban nor in the natural environment. Similar as in the MIST, within the FFT paradigm we observed a decrease in amygdala activity in women after the walk in nature, whereas it remained stable in men. Therefore, these results altogether suggest that the beneficial effects of nature on stress-related brain regions are more pronounced in women.

Interestingly, in the exploratory analysis we observed that the stronger connectedness to nature was in women, the change in their amygdala activity on the MIST after the city walk was higher, whereas no such association was found in men. Namely, the urban walk increased the stress-related neural activity during the social stress task more in women who are strongly connected to nature, than in those who feel less connected.

Moreover, the reaction time in the mental arithmetic task decreased only in the female subsample after the walk in nature, indicating that the natural environment was also more beneficial to cognition in women than in men. On the other hand, the reaction time decreased only in the male subsample after the urban walk, indicating that the walk in the urban environment was beneficial to cognition in men, but not in women. Interestingly, ART posits that nature restores attention, leading to better cognitive performance after nature exposure (Berto, 2014), however our results suggest that this effect is only observed in women, whereas men benefit cognitively from exposure to an urban environment. However, it should be highlighted that the cognitive performance was measured during the social stress task and therefore it might not be comparable with performance in a common working memory task within the ART approach (Ohly et al., 2016). On the other hand, the results showing a decrease in stress-related neural activity after the walk in nature in women are in accordance with SRT, which predicts that exposure to nature leads to recovery from stress.

To the best of our knowledge this is the first study to demonstrate differential tendencies in amygdala activity change in men and women as a causal effect of acute exposure to a natural vs. urban environment. The findings are in line with results from a pilot study showing that after 20-min exposure to an urban forest (Beil and Hanes, 2013), women reported greater decreases in stress than men. Furthermore, the difference in sex in relatedness to nature was also demonstrated in children, showing that girls reported a more intense positive affect related to natural stimuli (Bagot and Gullone, 2003; Larson et al., 2010), as well as a higher frequency of exposure to natural stimuli, whereas boys reported more intense positive affect related to non-natural stimuli (Bagot and Gullone, 2003). Given that women feel more connected nature (Zhang et al., 2014; Dean et al., 2018; Rosa et al., 2020), appreciate more its beauty more (Zhang et al., 2014) and care about the environment more than men (Zelezny et al., 2000), it might be that nature's relieving effect during social stress is therefore more pronounced in women.

Interestingly, in a previous study in which participants watched 3-D videos with different tree cover density, the relationship between stress recovery and tree densities showed an inverted U-shape in men. Namely, recovery from stress (measured by physiological stress indicators) was positively associated with

tree cover density, up to 24%. From 24 to 34% of tree cover density there was no change in stress recovery, whereas higher tree cover density was associated with slower recovery from stress (Jiang et al., 2014). The authors speculate that the slower stress recovery related to high tree density might have been associated with limited sky view and reduction in openness of space, present at higher tree densities. A previous study also reported that natural environments with low openness of space can increase levels of stress (Gatersleben and Andrews, 2013). Since in our study the path where the nature walk took place was mostly surrounded by high coniferous trees, the openness of space was low and the sky view was limited, which, as proposed in the aforementioned study, may have obstructed stress recovery in men after the walk in nature.

To date, few studies have shown that exposure to natural environments had a beneficial effect on cognition in women, whereas the exposure to the urban environment had a beneficial effect on cognition in men. On the other hand, these results are consistent with those of a previous study with children which showed a positive association between nature views from home and benefits in concentration and delayed gratification for girls, but not for boys (Taylor et al., 2002). In correspondence with our finding, it has been shown that stress impairs women's cognitive capacity, whereas it improves cognitive capacity in men (Schoofs et al., 2013) and leads to hyperarousal in women, but not in men (Bangasser et al., 2018). Given that arousal and cognitive performance have an inverted U-shaped relationship, with optimal arousal leading to optimal performance (Fisk et al., 2018), we speculate that the walk in nature decreased high arousal in women, leading to their better cognitive performance. In the same manner, since men under stress are less aroused than women (Bangasser et al., 2018) and stress enhances cognitive capacity in males (Schoofs et al., 2013), the walk in the urban environment, characterized by high social stress, could have increased their arousal and subsequently improved their cognitive performance. However, we have not explicitly tested for self-reported arousal levels after the stress-inducing fMRI paradigm and therefore we have no data on whether arousal levels differ between men and women before the walk. Thus, we recommend that future studies evaluate self-reported stress and arousal after the stress-inducing paradigm before the walk and directly after the walk.

There may also be additional limitations of the present study. The first limitation is a sample bias, since our sample consisted of young adults, mostly students from Germany, a WEIRD (Western, Educated, Industrialized, Rich, Democratic) country. Future studies should include participants from different age ranges, professions and cultures in order to overcome this bias and, especially, to examine the effect of interindividual differences, such as age, culture, personality traits etc. in experiencing urban and natural environments and in their influence on stress-related brain regions. Secondly, even though the MIST has been widely used to induce social stress in neuroimaging studies (Dedovic et al., 2009), social stress is induced by solving arithmetic tasks under time pressure, and therefore level of induced stress may depend on participants' mathematical skills. Considering that during social stress male participants performed better than female participants on the MIST and that a wide range of sociocultural factors contribute to sex differences in interests and achievements in mathematics (Halpern et al., 2007), we recommend that future studies that may choose to focus on sex differences should employ a social stress task that does not rely on participants' previous skills. Thirdly, as discussed in the previous paper (Sudimac et al., 2022), questionnaires given at pretest, before the walk, and at posttest, after the fMRI stress-inducing paradigm, that evaluated the affective state of the participants did not capture the effect of the walk itself, but rather the effect of the stress-inducing paradigm in the scanner and therefore were not used in the analysis with the fMRI data. Finally, it cannot be concluded which features of the nature exposure elicited the decrease in amygdala activity and the reaction time in women, as well as which aspects of the urban environment triggered the decrease in reaction time in men. We would therefore recommend that future studies differentially investigate distinct aspects of natural and urban environments, such as openness of the view, green color, number of people encountered in the environment, noise, odors etc. in order to disentangle specific features of these environments that impact stress-related brain regions.

To summarize, since there is a pronounced gap in the literature regarding interindividual differences in neural effects of exposure to natural vs. urban environments, we examined sex differences. We did so using a social stress paradigm and a fearful faces paradigm focused on activity in the amygdala, a stress-related brain region, as an effect of a one-hour walk in an urban vs. natural environment. We found that amygdala activity decreased after the walk in nature, but only in women, suggesting that women may profit more from the beneficial effects of nature. We also observed that the natural environment improved cognitive performance in women, whereas in men the cognitive performance improved after the walk in the urban environment.

This study is one of the first studies examining stress-related neural effects of an acute exposure to urban vs. natural environments. It is also a seminal study to examine interindividual differences in these effects, such as sex, and to report differential tendencies in men and women regarding their cognitive performance and stress-related neural correlates as a consequence of a short-term exposure to urban vs. natural environments. Therefore, we advise future research not to assume the same salutogenic effects for different population subgroups and to take participants' sex into account, as well as potentially other interindividual differences when investigating the effect of urban and natural environments on cognition, stress and underlying neural mechanisms. The results of this study are significant beacuse they suggest that natural and urban environments may affect men and women differently, which should be taken in account when designing urban green spaces in a way that would be optimal for citizens' mental health.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/jazqm/.

Ethics statement

The studies involving human participants were reviewed and approved by Local Psychological Ethical Committee at the Center for Psychosocial Medicine at University Medical Center Hamburg-Eppendorf in Hamburg, Germany. The patients/participants provided their written informed consent to participate in this study.

Author contributions

SS designed and coordinated the study, collected the data, performed data analysis, interpreted the results, and wrote the paper. SK had the idea for the study, designed and coordinated the study, supervised data acquisition and data analyses, interpreted the results, and reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.931905/full#supplementary-material

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Has the COVID-19 pandemic strengthened confidence in managing the climate crisis? Transfer of efficacy beliefs after experiencing lockdowns in Switzerland and Austria

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In the spring of 2020, countries introduced lockdowns as radical measures to deal with the first wave of the COVID-19 pandemic, which led to strong disruptions of people's everyday lives. Such drastic collective measures had previously seemed inconceivable in relation to other urgent crises, such as the climate crisis. In this paper, we ask how individual, participatory, and collective efficacy beliefs in dealing with the COVID-19 pandemic transferred to efficacy beliefs regarding the climate crisis. We present comparative results from two surveys: Study 1 assesses efficacy beliefs among German-speaking Swiss residents (n = 1,016), shortly after lockdown measures were relaxed. Study 2 compares changes in efficacy beliefs among Austrian high school students (n = 113) before and after the lockdown. In Study 1, climate-related self- and participatory efficacy are enhanced by the corresponding COVID-19-related beliefs. Climate-related efficacy beliefs mediate the effect of COVID-related counterparts on climate-friendly behavior and policy support. Study 2 shows that COVID-19-related efficacy beliefs are transferred to climate-related counterparts over time, and that the transfer of participatory efficacy is moderated by perceived similarity of the two crises. Experiencing successful individual and collective action during the COVID-19 pandemic seems to inspire confidence in dealing with climate change. Underlying processes (direct transfer, consistency, awareness-raising, learning) are discussed.

KEYWORDS

self-efficacy, participative efficacy, collective efficacy, efficacy affect, climate change mitigation, positive spillover, similarity

Introduction

Curbing climate change is one of the greatest challenges ever faced by humanity. Under the Paris Agreement, the international community has committed itself to limiting global warming to 1.5°C (United Nations, 2016). This means that greenhouse gas (GHG) emissions must be reduced to a net-zero level by 2050 at the latest

(IPCC, 2018). The attention to climate change temporarily dropped from public interest in the spring of 2020, however, as the world community was suddenly confronted with another global crisis, the rapidly spreading COVID-19 pandemic. Many governments responded with drastic measures in the form of lockdowns that greatly disrupted public life for a period of time. In this first phase of the COVID-19 pandemic, radical and comprehensive collective crisis management measures were passed, as had previously been demanded in vain in the face of the climate crisis (Reese et al., 2020). Due to pandemic restrictions, people were forced to cut back on consumption and mobility, which had a significant impact on individual and global greenhouse gas emissions (Forster et al., 2020; Le Quéré et al., 2020; United Nations Environment Programme, 2020). During the national lockdowns, people could thus experience how a life with a small GHG-footprint might feel, and what positive effects this could have on nature and human wellbeing (Garrido-Cumbrera et al., 2021). At the same time, this first wave of the COVID-19 pandemic was accompanied by a collective sense of solidarity as well as high public approval of the radical governmental measures taken (Austrian Corona Panel Project, 2020; Sotomo, 2020).

In this first wave of the COVID-19 pandemic, various voices expressed the (hopeful) expectation that experiencing these drastic lockdown measures in everyday life might open a window of opportunity for moving forward with stringent climate action (Reese et al., 2020; Lehmann et al., 2021). The first wave of the COVID-19 pandemic, during which this paper emerged, represented an unexpected real-world opportunity to gain a better understanding of the extent to which, and mechanisms by which, learning from one crisis to deal with another might take place. We wondered whether people's experiences of coping with the COVID-19 pandemic formed corresponding efficacy beliefs that might transfer to efficacy beliefs and behaviors regarding the climate crisis. In this paper, we report the results of two surveys in Switzerland and Austria that were conducted after the national lockdowns ended in the late spring of 2020. Our results suggest that COVID-19-related efficacy beliefs inform the corresponding climate-related efficacy beliefs, even when controlling for climate-related self-identity or the stability of climate-related efficacy beliefs over time.

Efficacy beliefs as antecedents of climate-friendly private and public behavior

Efficacy beliefs have been shown to be an important predictor of climate-friendly behavior in previous research. Based on social cognitive theory (Bandura, 1997, 2006), different types of efficacy beliefs have been explored in the context of pro-environmental and climate-friendly behavior: self-, collective and participatory efficacy, and efficacy affect.

Self-efficacy refers to an individual's belief in being capable of performing a certain action (behavioral self-efficacy; Bandura, 1997), or achieving a certain goal (goal-oriented self-efficacy; Hamann and Reese, 2020), sometimes also referred to as response self-efficacy (Bostrom et al., 2019; Brügger et al., 2020). In environmental psychology, goal-oriented self-efficacy is understood as "an individual's perception of his or her ability to effect positive change regarding the environment" (Sawitri et al., 2015, p. 30). Self-efficacy beliefs thus encourage people to adopt an active, problem-oriented, that is to say, mitigating role in the face of personal or social crises (Homburg and Stolberg, 2006). Several empirical studies underpin the relevance of self-efficacy beliefs for pro-environmental and climate-friendly consumption behavior (known as private sphere behavior, e.g., Tabernero and Hernández, 2011; Hunter and Röös, 2016; Reese and Junge, 2017; Loy et al., 2020), and for an active role in the climate strike movement (known as activism, e.g., Brügger et al., 2020; Cologna et al., 2021), as well as for the support of climate policies (known as public behavior, e.g., Bostrom et al., 2019).

The climate crisis does not present itself only as an individual task in shaping one's own climate-friendly lifestyle, however, but rather as a comprehensive, global problem that requires collective action by all actors at all levels (Capstick et al., 2014; Amel et al., 2017). Given this collective challenge and the required collective solutions, psychological research has increasingly addressed efficacy beliefs with particular explanatory power for activist behavior or public support of climate policies. *Collective efficacy* is understood as the belief that a collective or a group can achieve certain goals and thus contribute to crisis management (Bandura, 1997; Fritsche et al., 2018; Reese et al., 2020). Various studies show empirically that collective efficacy beliefs are associated with both private behavior and public behavior (e.g., Rees and Bamberg, 2014; Barth et al., 2016; Reese and Junge, 2017; Sabherwal et al., 2021). In some cases, self-efficacy is found to be a better predictor of private-sphere behavior and collective efficacy a better predictor of public behavior (Jugert et al., 2016; Hamann and Reese, 2020).

Even free-riders may hold strong collective efficacy beliefs, however, and may presume that others will reach for the common goals without themselves taking an active part (Hamann et al., 2021). *Participatory efficacy*, therefore, encompasses the belief that one's own contribution makes a significant difference to reaching the collective goals (van Zomeren et al., 2013). Participatory efficacy links self- and collective efficacy by focusing on one's own agency within the framework of the collective (Meijers et al., 2021). Various empirical studies report that participatory efficacy has better predictive power than collective efficacy (van Zomeren et al., 2013, 2018; Bamberg et al., 2015; van den Broek et al., 2019).

Efficacy beliefs have not just a cognitive, but also an affective component. *Efficacy affect* comprises emotions toward anticipated future outcomes, just as efficacy beliefs are directed to a certain action or goal (Geiger et al., 2021c). Positive affect,

such as hope or enthusiasm, reflects an emotional state of optimistic expectations about the future. Conversely, negative affect, such as frustration or helplessness, signals futility and lack of confidence in attaining a desired outcome. Emotional states are a source of self-efficacy and other efficacy beliefs (Bandura, 1977; Hamann et al., 2021); for instance, being positively moved is related to collective efficacy (Landmann and Rohmann, 2020). Positive affect predicts pro-environmental behavior (Hamann and Reese, 2020; Hamann et al., 2021). Hostile emotions, such as anger and outrage, instigate collective action when protesting against personal deprivation and injustice (Bamberg et al., 2015); by contrast, pro-environmental activists, who are rarely disadvantaged in their personal livelihood by the topics they act on, are motivated by feelings of hope or of being moved (Landmann and Rohmann, 2020; Geiger et al., 2021c).

Apart from their direct predictive power, efficacy beliefs are assumed to function as a mechanism when learning from one context to deal with another (Nash et al., 2017). Performance accomplishments, that is to say, previous experiences of mastering challenges, are a source of self-efficacy (Bandura, 1977). In this sense, successfully employing personal capabilities when coping with the COVID-19 crisis can be expected to influence efficacy beliefs toward other crises. Efficacy beliefs are discussed as a mechanism for positive spillover, which is the phenomenon when performing an initial pro-environmental behavior increases the likelihood of performing other pro-environmental actions later or in a different context (Nilsson et al., 2017; Carrico, 2021). Accomplishing the initial behavior supposedly reinforces corresponding efficacy beliefs, which then promote other pro-environmental actions (Thøgersen and Crompton, 2009). The role of efficacy beliefs as spillover mechanism is, however, debated (Lauren et al., 2016; Egner and Klöckner, 2021). In direct comparison, ecological self-identity emerges as a more relevant mediator for spillover than efficacy beliefs (Lauren et al., 2019). Spillover is more likely between behaviors from a similar functional category or directed toward a similar goal (Lauren et al., 2016; Nash et al., 2017; Höchli et al., 2019). If similarity moderates the transfer between behaviors, it seems plausible that similarity also guides the transfer of efficacy beliefs. All the same, recent meta-analyses caution against expecting substantial spillover effects in behaviors (Maki et al., 2019; Geiger et al., 2021a).

Perceived similarity and transfer between the COVID-19 pandemic and the climate crisis

The notion of learning from COVID-19 for the climate crisis had already been put forward at the beginning of the pandemic (Reese et al., 2020; Lehmann et al., 2021). Several studies examine similarities in the public perception of the COVID-19 crisis and the climate crisis: Bostrom et al. (2020) find that U.S. citizens perceive both crises as highly threatening and hardly controllable. The climate crisis is considered to be better understood, however, and people think that they can contribute more to mitigating the COVID-19 crisis, and feel a greater moral responsibility to do so, compared to the climate crisis. In Geiger et al. (2021b), U.S. citizens report more perceived similarities between the two crises than perceived differences. Emotional evaluation of the crises had greater explanatory power for crisis-related behaviors in the case of the climate crisis than in the case of the COVID-19 crisis; however, both studies remain at a descriptive level and do not investigate possible transfer processes between the two crises.

To the best of our knowledge, only a few studies compare the effect of efficacy beliefs on climate- and pandemic-related behavior. Meijers et al. (2021) find in a Dutch sample that COVID-19-related participatory efficacy predicts pandemic-mitigating behavior, and climate-related participatory efficacy predicts climate change-mitigating behavior; however, this study does not test for transfer processes between the two crises. By contrast, Lucarelli et al. (2020) find in an Italian student sample that perceptions of existing interdependencies between the COVID-19 crisis and the climate crisis strengthen the link between perceived behavioral control (a construct related to self-efficacy; Ajzen, 2002) and climate-related behavioral intentions, as well as corresponding private behavioral implementation.

Present research

This paper reports the results of two studies that were conducted as an *ad hoc* cooperation at the beginning of the pandemic lockdowns in spring 2020 in two different countries. Study 1 was part of a large-scale survey on the experience and reactions during the lockdown in Switzerland. Study 2 extended an already planned longitudinal study on climate attitudes and behaviors among high school students in Austria. Both studies apply identical questionnaire items and complement each other in terms of survey design, sample size, and representativeness. Both studies should be considered exploratory as they reacted to the novelty and research opportunity of the pandemic situation in spring 2020 and the short timeframe when lockdowns were lifted; therefore, the studies were not preregistered.

Both studies address two overarching research questions. First, we analyze whether COVID-19-related efficacy beliefs directly inform corresponding climate-related efficacy beliefs; in other words, we test for their positive association. Therein, we take up the argumentation that the pandemic experience demonstrated individual and collective capabilities that may transfer to coping with the climate crisis (Lauren et al., 2019; Reese et al., 2020; Lehmann et al., 2021). Second, we explore mechanisms, conditions, and behavioral effects related with the transfer of efficacy beliefs. Concordant with the perspective on efficacy beliefs as spillover mechanism, Study 1 tests whether the

effect of COVID-19-related efficacy beliefs on different climate-friendly behavioral responses is mediated via the corresponding climate-related efficacy beliefs (Lauren et al., 2016). In line with the perspective that spillover is more likely to occur between similar contexts, Study 2 tests whether the effect of COVID-19- on climate-related efficacy beliefs is moderated by the perceived similarity between the COVID-19 and the climate crisis (Lauren et al., 2016; Maki et al., 2019).

Study 1

Study 1 tests a mediation model in which COVID-19-related efficacy beliefs are assumed to inform corresponding climate-related efficacy beliefs and thus indirectly affect corresponding climate-friendly behavioral responses, namely individual private-sphere pro-environmental behavior and policy support (see Figure 1). We thus refer to the two overarching research questions, in other words, the assumed positive relationship between COVID-19-related and climate-related efficacy beliefs, and the assumed indirect effect of COVID-19-related efficacy beliefs on climate-friendly private behavior and policy support. Previous studies have shown that both, self-identity and self-efficacy have the potential to promote spillover effects (Lauren et al., 2016, 2019). We therefore included self-identity to test whether self-efficacy leads to transfer effects even when self-identity is controlled.

Methods

Participants

Study 1 was conducted as a cross-sectional survey from May 07-14, 2020, just as the first lockdown in Switzerland, which had started on March 16, was gradually lifted. In addition to the contents reported in this paper, the survey captured changes in time use, consumption behavior, and wellbeing during the lockdown. A sample of German-speaking Swiss residents aged 18 to 65 was recruited from an existing panel of a survey institute (Intervista), with quotas set by gender, age, and education. Participants were invited to a standardized online questionnaire by the survey institute and were rewarded for completing the survey with the institute's point-based voucher system. The invitation was made by the panelist institute, i.e., the researchers did not have personal or contact information at any time, and the panelist institute did not have access to the participants' responses. The panelists were persons who had in principle given consent to the panelist institute to participate in surveys and they could decline the invitation to this particular study. On the survey landing page, the participants were informed about the purpose and conditions (e.g., anonymity, confidentiality, voluntariness, option to cancel or interrupt) of the study and had to explicitly state their informed consent before starting the survey. In total, 1,176 participants were invited, of whom 1,051 (89.4%) completed the survey. Thirty-five "speeders" were excluded who completed the questionnaire in <10 min (average completion time: 21 min). This yielded a sample of $n = 1{,}016$ participants for analysis (net sample = 86.4%).

Participants were not required to respond to all items, so the number of missing values varies between items. All Study 1 results are calculated applying listwise exclusion of missing values which reduces the sample size marginally to $n = 985$–994. The sex ratio of the sample was 50%, as targeted, and the mean age was 43.07 years ($SD = 13.26$). Household size averaged 2.43 persons ($SD = 1.21$, with a $min = 1$ and $max = 8$). 1.1% had not concluded compulsory education, 4.6% reported compulsory education as their highest level of education, 54.8% had a vocational apprenticeship or vocational school diploma, 10.3% had a high school degree (Maturität), and 27.9% had a university degree. These sociodemographic characteristics indicate to a high diversity of the sample that is not equivalent but comparable to the Swiss resident population in terms of age, gender, family size, and educational degree (Federal Statistical Office, n.d; Federal Statistical Office., 2021).

Procedure and materials

For detailed wording (translated from German), descriptive statistics, and scale reliabilities of all items please refer to Supplementary Table S1. Efficacy beliefs were assessed as two distinct factors, referring to agency as an individual (*self-efficacy*, two items; e.g., "I am confident that I can do something for climate protection on my own"), and as a member of a group (*participatory efficacy*, two items; e.g., "I am capable of making a small but important contribution to improving climate protection together with others"). Item wordings were informed by previous studies (Bamberg et al., 2015; Lauren et al., 2016; Hamann et al., 2021). The wording was adjusted to create parallel versions of these items referring to either climate protection or tackling the COVID-19 crisis. Responses were given on a rating scale from "strongly agree" (5) to "strongly disagree" (1). Cronbach's alpha for these four factors ranged from $\alpha = 0.75$ to $\alpha = 0.86$, indicating good scale reliability (Bortz and Döring, 2006). Items assigned to the respective factors were aggregated to mean factor indices to correct for measurement error of single items; thus, the unstandardized regression coefficients of factors reported in the Results section of Study 1 below use the same five-step scale as the single items. Intercorrelations of the different efficacy beliefs are between $r = 0.29$ and $r = 0.60$ (see Supplementary Table S2).

Climate change-related behavior responses (the outcome variables) were assessed as two different behavioral responses: considering the COVID-19 crisis as a window of opportunity for radical climate policies (*policy support,* four items based on own wording, $\alpha = 0.82$; e.g., "To protect the climate, I would welcome profound governmental measures similar to those taken to

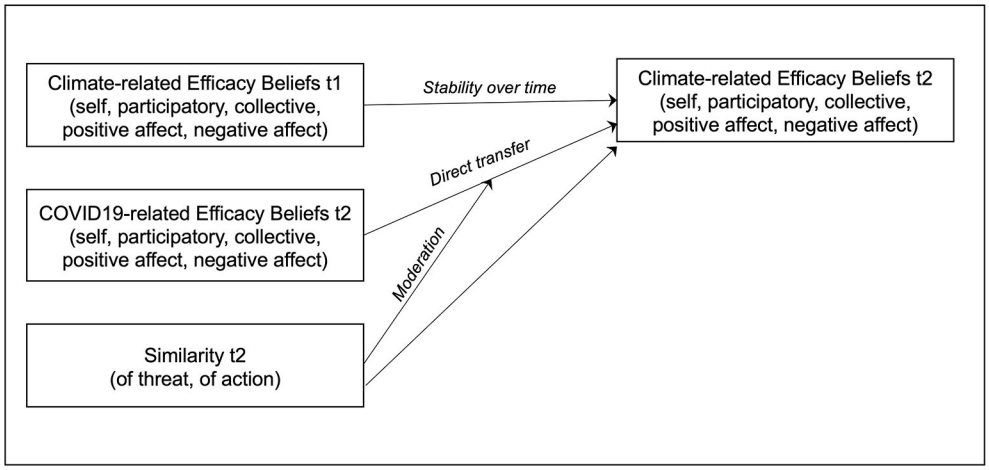

FIGURE 1
Mediation model of Study 1 assuming an indirect effect of COVID-19-related efficacy beliefs on climate-friendly behavioral responses *via* climate-related efficacy beliefs (The labeling of the paths facilitates interpretation of the estimates in Tables 1, 2).

combat the COVID-19 pandemic"); environmentally friendly private behavior during the COVID-19 lockdown (seven items based on own wording, applying an answer scale from (5) "fully true" to (1) "not true at all," $\alpha = 0.71$; e.g., "I have repaired items that were broken"). For both factors, again, mean factor indices were formed for the further analyses.

For measuring *climate-related self-identity* (the covariate), three items were slightly adapted from Van der Werff et al. (2014; e.g., "I am the type of person who acts in a climate-friendly way"); these items used the "strongly agree" (5) to "strongly disagree" (1) rating scale and were aggregated to a mean index ($\alpha = 0.92$). Items assessing climate-related efficacy beliefs, public behavior, and climate-related self-identity were presented in the same block in randomized order. Items on COVID-19-related efficacy and private behavior were each presented in separate blocks.

Analytical approach

Study 1 tests four versions of the mediation model in Figure 1, which assumes that the predictor COVID-19-related efficacy indirectly affects the outcome variable climate-relevant private behavior and policy support (the latter as a specific case of public behavior) *via* the mediator variable climate-related efficacy while controlling for the covariate climate-related self-identity. We calculated four regression models, each combining self- or participatory efficacy with private behavior and policy support. We calculated, following Hayes (2018) and Hayes and Rockwood (2017) the direct, the indirect, and the total effects of efficacy beliefs on behavioral responses using the PROCESS program for SPSS. We first regressed the mediator variable on the predictor and the covariate, and second, we regressed the outcome variable on the predictor, the mediator, and the covariate. The indirect effect of the predictor *via* a mediator on the outcome variable results from the product of the path estimates a and b (cp. Figure 1). All results are tested against $p < 0.05$, $p < 0.01$, and $p < 0.001$ significance levels. Modified Breusch-Pagan tests for heteroscedasticity were significant for three of the four models, we thus applied robust standard errors (HC3 Davidson McKinnon) and covariance matrix estimators. Moreover, we report 10,000 bootstrapped confidence intervals.

Results

We first test for the assumption of positive associations between COVID-19-related and climate-related efficacy beliefs. As shown in the leftmost part of Table 1, the mediator variable climate-related self-efficacy is statistically significantly predicted by the predictor COVID-19-related self-efficacy ($a = 0.22^{***}$), and the covariate climate-related self-identity ($f = 0.65^{***}$, $R^2 = 0.48$). Table 2 reveals a comparable picture: The mediator climate-related participatory efficacy is predicted by COVID-19-related participatory efficacy ($a = 0.31^{***}$), as well as climate-related self-identity ($f = 0.60^{***}$, $R^2 = 0.40$). Our assumption of a positive relationship between the efficacy beliefs of both crises is thus confirmed for self-efficacy as well as for participatory efficacy.

Second, we test for the hypothesized indirect effect of COVID-19-related efficacy beliefs on climate-friendly behavioral responses *via* climate-related efficacy beliefs. The estimates in the medium part of Table 1 show that policy support is predicted by statistically significant direct effects of the predictor COVID-19-related self-efficacy ($c' = 0.10^{**}$), the

TABLE 1 Model coefficients for the mediation model assuming an indirect effect of COVID-19-related self-efficacy on behavioral responses *via* climate-related self-efficacy, with self-identity as covariate.

	Self-efficacy (Climate)					Policy support					Private behavior				
Predictor	**Parameter**	**Estimate**	***SE***	***p***	**95% C.I. (LL, UL)**	**Parameter**	**Estimate**	***SE***	***p***	**95% C.I. (LL, UL)**	**Parameter**	**Estimate**	***SE***	***p***	**95% C.I. (LL, UL)**
Constant	i_M	0.70	0.12	0.000	(0.46, 0.94)	iy	0.86	0.15	0.000	(0.57, 1.14)	i_y	1.64	0.12	0.000	(1.41, 1.88)
Self-efficacy (COVID-19)	*a*	0.22	0.03	0.000	(0.17, 0.27)	c'	0.10	0.03	0.001	(0.04, 0.17)	*c'*	0.13	0.03	0.000	(0.08, 0.18)
Self-efficacy (Climate)		-	-	-	-	b	0.22	0.04	0.000	(0.13, 0.30)	*b*	0.07	0.04	0.051	(−0.00, 0.15)
Self-identity (Climate)	*f*	0.65	0.03	0.000	(0.60, 0.71)	g	0.41	0.04	0.000	(0.32, 0.49)	*g*	0.16	0.04	0.000	(0.09, 0.23)
		$R^2 = 0.48$					$R^2 = 0.31$					$R^2 = 0.11$			
		$F(2, 988) = 401.12, p < 0.001$					$F(3, 987) = 136.12, p < 0.001$					$F(3, 990) = 39.73, p < 0.001$			
		$N = 991$					$N = 991$					$N = 994$			

Parameters correspond to the paths in Figure 1. Estimate, unstandardized regression coefficient; SE, robust standard error (HC3), 95% C.I. (LL, UL) = 95% bootstrap confidence interval (lower level, upper level).

TABLE 2 Model coefficients for the mediation model assuming an indirect effect of COVID-19-related participatory efficacy on behavioral responses *via* climate-related participatory efficacy, with self-identity as covariate.

	Participatory efficacy (Climate)					Policy support					Private behavior				
Predictor	**Parameter**	**Estimate**	***SE***	***p***	**95% C.I. (LL, UL)**	**Parameter**	**Estimate**	***SE***	***p***	**95% C.I. (LL, UL)**	**Parameter**	**Estimate**	***SE***	***p***	**95% C.I. (LL, UL)**
Constant	i_M	−0.18	0.12	0.127	(−0.42, 0.05)	iy	1.06	0.14	0.000	(0.79, 1.33)	i_y	1.67	0.12	0.000	(1.44, 1.90)
Participatory efficacy (COVID-19)	*a*	0.31	0.03	0.000	(0.25, 0.37)	c'	0.07	0.03	0.011	(0.02, 0.13)	*c'*	0.13	0.03	0.000	(0.08, 0.18)
Participatory efficacy (Climate)		-	-	-	-	b	0.24	0.03	0.000	(0.18, 0.31)	*b*	0.08	0.03	0.008	(0.02, 0.14)
Self-identity (Climate)	*f*	0.60	0.03	0.000	(0.54, 0.67)	g	0.40	0.04	0.000	(0.32, 0.47)	*g*	0.16	0.03	0.000	(0.09, 0.22)
		$R^2 = 0.40$					$R^2 = 0.33$					$R^2 = 0.12$			
		$F(2, 982) = 368.35, p < 0.001$					$F(3, 981) = 158.73, p < 0.001$					$F(3, 983) = 43.12, p < 0.001$			
		$N = 985$					$N = 985$					$N = 987$			

Parameters correspond to the paths in Figure 1. Estimate, unstandardized regression coefficient. SE, robust standard error (HC3), 95% C.I. (LL, UL) = 95% bootstrap confidence interval (lower level, upper level).

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mediator climate-related self-efficacy ($b = 0.22^{***}$), and the covariate self-identity ($g = 0.41^{***}$, $R^2 = 0.31$). The indirect effect of COVID-19-related self-efficacy *via* climate-related self-efficacy results from the product of the parameters $a^*b = 0.22^*0.22 = 0.05$ and is statistically significant (*SE(HC3)* = 0.01, $Z = 4.30$, $p = 0.000$, 95% C.I. [0.03, 0.07]) according to Sobel's test (Hayes, 2018). The total effect of COVID-19-related self-efficacy on policy support behavior amounts to $c = c'+a^*b = 0.15$ ($p = 0.000$, 95% C.I. [0.09, 0.21]). Thus, when controlling for climate-related self-identity, the influence of COVID-19-related self-efficacy on policy support is partially mediated by climate-related self-efficacy.

The center part of Table 2 shows the same mediation analysis for participatory efficacy. We find a statistically significant indirect effect of COVID-19-related participatory efficacy via climate-related participatory efficacy on policy support ($a^*b = 0.31^*0.24 = 0.07$, *SE(HC3)* = 0.01, $Z = 5.91$, $p = 0.000$, 95% C.I. [0.05, 0.10]). The total effect of COVID-19-related participatory efficacy on public support amounts to $c = c'+a^*b = 0.15$ ($p = 0.000$, 95% C.I. [0.09, 0.21]). Thus, COVID-19-related participatory efficacy also shows partial mediation *via* climate-related participatory efficacy on policy support while controlling for climate-related self-identity.

Finally, we repeat the mediation analysis for climate-friendly private behavior during the COVID-19 lockdown. The first regression step involving efficacy beliefs and self-identity is identical to the above results on policy support. As can be seen from the right-hand part of Table 1, in the second regression step, the effect of the mediator climate-related self-efficacy on private behavior does not reach statistical significance ($b = 0.07^{n.s.}$). Consequently, the indirect effect of COVID-19-related self-efficacy on private behavior does not reach significance either ($a^*b = 0.22^*0.07 = 0.02$, *SE(HC3)* = 0.01, $Z = 1.90$, $p = 0.058$, 95% C.I. [0.00, 0.03]). The total effect is significant ($c = c'+a^*b = 0.15$, $p = 0.000$, 95% C.I. [0.09, 0.20]) due to a significant direct effect of COVID-19-related self-efficacy ($c' = 0.13^{***}$). Thus, environmentally friendly everyday activities during the lockdown cannot be attributed to an increased climate-related self-efficacy. By contrast, the indirect effect of COVID-19-related participatory efficacy *via* climate-related participatory efficacy on private behavior proves statistically significant ($a^*b = 0.31^*0.08 = 0.03$, *SE(HC3)* = 0.01, Z = 2.55, $p = 0.011$, 95% C.I. [0.01, 0.05]). The total effect of COVID-19-related participatory efficacy on private behavior is also significant ($c = c'+a^*b = 0.16$, $p = 0.000$, 95% C.I. [0.11, 0.21]), as is the direct effect of COVID-19-related participatory efficacy on private behavior ($c' = 0.13^{***}$). This partial mediation suggests that people who were convinced of their personal contribution in collectively mastering the COVID-19 crisis also carried out more environmentally friendly activities in their private lives during the lockdown.

Discussion

The results of Study 1 confirm the hypothesized positive associations between COVID-19-related and climate-related beliefs for self- and participatory efficacy. Both COVID-19-related self- and participatory efficacy indirectly translate (*via* partial mediation by climate-related efficacy) into increased support for radical and comprehensive climate-protective policies similar to those used to combat the pandemic. Indirect transfer *via* partial mediation also applies to the effect of COVID-19-related participatory efficacy on private environmentally friendly action during the pandemic lockdown. Only for self-efficacy and private behavior can the assumed mediating effect not be confirmed when controlling for self-identity. Thanks to a comment from an anonymous reviewer, we re-analyzed our models without the covariate self-identity to exclude a possible confounding effect of self-identity. The results can be found in Supplementary Tables S3, S4. Without the covariate self-identity, all four mediation analyses proved to be statistically significant, i.e., also the partial mediation effect of self-efficacy on private behavior (with an indirect effect of $a^*b = 0.33^*0.17 = 0.06$, *SE(HC3)* = 0.01, $Z = 5.31$, $p = 0.000$, 95% C.I. [0.04, 0.08], and a total effect of $c = c'+a^*b = 0.18$ ($p = 0.000$, 95% C.I. [0.13, 0.23]). This re-analysis suggests that self-identity acts as an important confounder, at least in this latter case, and that it important to consider self-identity also in corresponding future analyses.

The Study 1 results are, however, based on cross-sectional data; thus, the causality of the relationships within the tested mediation model relies on theoretical assumptions, and the correlational data would also allow for the opposite causal direction of climate-related on COVID-19-related efficacy beliefs. Moreover, Study 1 does not make any statements about conditions under which the transfer of efficacy beliefs between both crises becomes more likely. Both of these limitations are addressed in Study 2.

Study 1 relies on self-reported, not observed behavioral measures that only capture a limited range of climate-related actions Swiss citizens may take. Private behavior as measured in Study 1 encompasses rather general ecological domains which the lockdown provided an opportunity to discover (e.g., repairing and decluttering personal belongings). Private behavior does not include carbon-intensive behaviors because these were restricted for all during the lockdown (e.g., everyday transport, holiday travel) or were unlikely to shift from established patterns (e.g., domestic heating). Support of climate policy is a very specific case of public behavior and does not include political activism. Partial congruence between general efficacy beliefs related to climate protection and selected specific behaviors could be a reason for statistically weak effects.

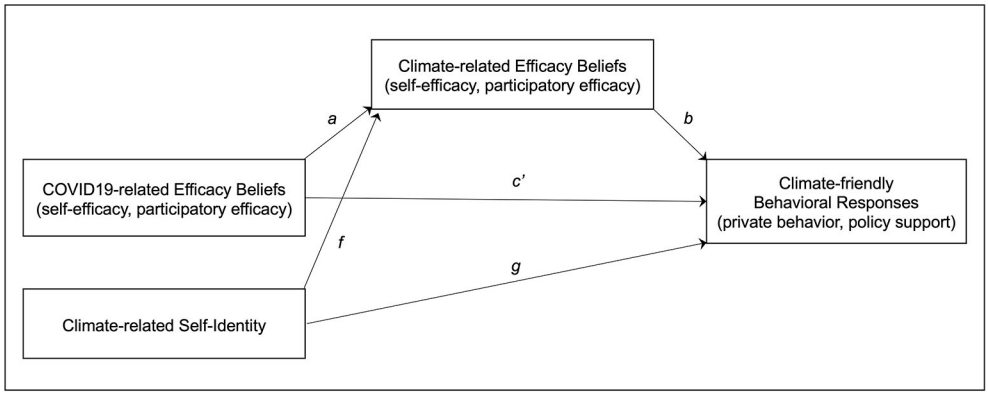

FIGURE 2
Moderation model of Study 2 assuming that the transfer of efficacy beliefs between the COVID-19 and the climate crises is more likely if the two crises are perceived as similar.

Study 2

Study 2 tests a moderation model in which the effect of COVID-19-related efficacy beliefs on climate-related efficacy beliefs is assumed to depend on the perceived similarity of the two crises (see Figure 2). We thus refer to our two overarching research questions, that is to say, the assumed positive relationship between COVID-19-related and climate-related efficacy beliefs, and that transfer of efficacy beliefs is more likely between contexts perceived as similar. We test whether the relationships for self-efficacy and participatory efficacy observed in Study 1 can be replicated with longitudinal data. In addition, we test the proposed model for collective efficacy, and positive and negative efficacy affect.

Methods

Participants

Study 2 was implemented as a longitudinal survey among Austrian high school students before and after the COVID-19 school closures in Spring 2020. In February to March 2020, just before the national lockdown started, students in their final high school year (12^{th} or 13^{th} year of formal education) were surveyed as part of a research project on climate attitudes and behaviors (first survey wave, t1). In May 2020, after quarantine rules had been relaxed and teaching in classrooms recommenced, these students were approached again (second survey wave, t2).

At t1, students in four general and two vocational secondary schools in the Austrian province of Styria completed standardized electronic questionnaires in the classroom during school hours. A researcher was present on-site for oversight and clarification. At t2, those students who had provided valid contact data at t1, received an email invitation to an online questionnaire, followed by up to two reminder emails. In total, 300 students participated at t1; 231 students gave contact data at t1; 113 students participated at t2, amounting to a response rate of 49% and yielding a longitudinal sample for analysis of $n = 113$ cases. Respondents were aged 16 to 20 years (mean = 17.9, $SD = 0.79$) and 53.1% female. The age distribution remained fairly constant from t1 to t2; however, male students and students from vocational schools were less represented at t2 (Supplementary Table S5 details sample dropout from withholding contact data or panel attrition). The data do not include any missing values in any variables.

Study 2 was conducted in line with the ethics guidelines of the authors' home institutions and of the provincial school boards in Austria. In Study 2, 65.5% of the subjects were of legal age of 18 years; by Austrian law, youths of 14 years are legally competent for minor commercial activities including the use of online services. The Study 2 questionnaire included an introduction stating the study purpose and ensuring confidentiality of information (in particular with regards to teachers, parents or peers), and a detailed data protection statement. Survey participation was voluntary; even in the classroom at t1, students could cancel the survey and delete all responses at any point of the questionnaire.

Procedure and materials

For detailed wording (translated from German), descriptive statistics, and scale reliabilities of all items please refer to Supplementary Table S6. Efficacy beliefs were assessed as three distinct factors, referring to the agency as an individual (*self-efficacy*, three items, two of which were phrased identically as in Study 1), as a member of a group (*participatory efficacy*, three items, two of which were phrased as in Study 1) and as a whole group (*collective efficacy*, three items; e.g., "Through collective efforts of myself and other people, we can achieve

progress in climate protection"; van Zomeren et al., 2013; Bamberg et al., 2015; Lauren et al., 2016; Hamann et al., 2021). Emotions associated with efficacy were measured as *positive efficacy affect* (feeling hopeful or motivated, two items; Hamann and Reese, 2020) and as *negative efficacy affect* (feeling helpless or frustrated, two items; Geiger et al., 2021c). Efficacy items were phrased identically for climate and COVID-19, apart from specifying the goal of either climate protection or tackling the pandemic. Responses were given on a rating scale from "fully agree" (5) to "fully disagree" (1). Items on participatory and collective efficacy referred to the ingroup of other young people regarding the climate crisis, and to the ingroup of other people regarding the COVID-19 crisis. Climate-related efficacy beliefs were measured at t1 and t2. COVID-19-related efficacy beliefs were measured only at t2, because at t1 COVID-19 had not yet been an issue neither to us researchers nor to the students.

For assessing perceived similarity between the two crises, respondents were asked at t2 to compare both crises on ten attributes using a five-step bipolar rating scale from "very similar" (+2) to "very dissimilar" (-2). The attributes reflected hazard characteristics identified in the psychometric risk paradigm (originally by Fischhoff et al., 1978) such as dread potential, scientific knowledge, or control over the hazard. *Post hoc* principal component analysis suggested aggregating seven of these attributes to two factors (Supplementary Table S7): *similarity of threat*, considering COVID-19 and climate as pressing and hard-to-manage crises that both require precautionary and collaborative efforts (four items) and *similarity of action*, considering both COVID-19 and climate as crises that can be effectively managed by the state in the short term (three items).

Items were presented in mixed order in the questionnaire to avoid artificial inflation of intra-scale correlations. As in Study 1, items assigned to the respective factors were aggregated to mean factor indices; thus, the unstandardized regression coefficients of factors reported in the Results Section of Study 2 below use the same five-step scale as the single items. Most indices have reliability scores of Cronbach's $\alpha > 0.60$ or higher, apart from positive efficacy affect and similarity of action ($\alpha = 0.55$ and $\alpha = 0.52$); however, all items comply with the common threshold of an item-total correlation $r_{it} > 0.30$ with their respective index. Short scales consisting of only a few items are generally susceptible to weak reliability (Bortz and Döring, 2006). Mean factor indices of efficacy beliefs intercorrelate moderately at $r < 0.60$, thus indicating satisfactory discriminant validity (Supplementary Table S8). However, self-efficacy and participatory efficacy correlate at $r = 0.60$ to.70, and participatory efficacy and collective efficacy correlate at $r = 0.70$–0.80, which might point to a shared background variable such as general efficacy beliefs or locus of control. Still, for conceptual completeness all efficacy beliefs are analyzed separately.

Analytical approach

We calculated ten separate regression models each combining a specific efficacy belief (self, participatory, collective, positive affect, negative affect) with a specific similarity (threat, action). All models have the same structure, regressing climate-related efficacy beliefs at t2 on three predictors (Figure 2): (1) climate-related efficacy beliefs at t1 to control for the autoregressive effect and to show how stable efficacy beliefs are over time; (2) the counterpart COVID-19-related efficacy at t2 to determine its unique additional effect and to show whether efficacy beliefs are directly transferred from COVID-19 to climate; and (3) similarity to show whether the perceived attributes of the COVID-19 crisis change climate-related efficacy. As a transfer of efficacy beliefs is more likely between similar contexts, the models include a COVID-19-related efficacy x similarity interaction term to check for a moderator effect, in other words, whether transfer of efficacy beliefs is more pronounced the more similar both crises are perceived to be. This regression approach serves the dual purpose of showing the stability of climate-related efficacy beliefs, and analyzing how much of the individual variance left unexplained by stability can be traced back to the influence of COVID-19-related efficacy beliefs.

The influence of climate-related efficacy at t1 may be interpreted as a common main effect; however, the influences of COVID-19-related efficacy beliefs and similarity are conditional simple effects because these predictors are also included in the interaction term and are therefore mean-centered for clearer interpretation (Hayes, 2018). Index intercorrelations $r < 0.66$ suggest that there are no issues of multicollinearity among the predictors (Iacobucci et al., 2016). All results are tested against $p < 0.05$ and $p < 0.01$ significance levels. Note that we expect positive signs of the regression coefficients in the models on positive as well as negative efficacy affect, as the affective state is transferred from t1 to t2 or from the COVID-19 to the climate crisis regardless of whether the transferred emotions are positive or negative.

Results

Tables 3, 4 give the regression results; each column reports a separate model that refers in all climate- and COVID-19-related efficacy factors to the same specific efficacy belief (self, participatory, etc.). As an example, we interpret the unstandardized regression coefficients in the model on climate-related self-efficacy and similarity of threat (furthest left column in Table 3): An increase in climate-related self-efficacy at t1 by one step on the five-step response scale leads to an increase in climate-related self-efficacy at t2 by 0.52 steps ($b = 0.52^{**}$). This indicates high stability over time. The coefficients of COVID-19-related self-efficacy and similarity of threat have to be read as conditional on the other component of the interaction term:

TABLE 3 Model coefficients for moderation models assuming a moderating effect of perceived similarity of threat on the transfer of COVID-19-related efficacy beliefs on climate-related efficacy beliefs.

Predictor	Efficacy (Climate) t2				
	Self	Participatory	Collective	Positive affect	Negative affect
Constant	1.86 (0.30)**	1.69 (0.25)**	1.48 (0.32)**	1.50 (0.22)**	1.56 (0.22)**
Efficacy (Climate) t1	0.52 (0.09)**	0.54 (0.07)**	0.60 (0.08)**	0.53 (0.07)**	0.43 (0.07)**
Efficacy (COVID-19) t2	0.19 (0.08)*	0.10 (0.10)	0.14 (0.11)	0.29 (0.08)**	0.24 (0.08)*
Similarity of threat t2	0.16 (0.08)*	0.31 (0.08)**	0.18 (0.09)	0.22 (0.08)**	−0.03 (0.10)
Interaction efficacy (COVID-19) × Similarity of threat	−0.00 (0.08)	0.00 (0.11)	0.07 (0.12)	0.06 (0.09)	0.04 (0.10)
R^2	0.42	0.52	0.46	0.52	0.34
F (df1 = 4/df2 = 108)	19.33**	29.10**	23.36**	28.53**	13.67**

*p < 0.05, **p < 0.01. n = 113. Unstandardized regression coefficients b with standard errors (SE) in parentheses.

TABLE 4 Model coefficients for moderation models assuming a moderating effect of perceived similarity of action on the transfer of COVID-19-related efficacy beliefs on climate-related efficacy beliefs.

Predictor	Efficacy (Climate) t2				
	Self	Participatory	Collective	Positive affect	Negative affect
Constant	1.76 (0.30)**	1.52 (0.26)**	1.44 (0.31)**	1.41 (0.22)**	1.54 (0.22)**
Efficacy (Climate) t1	0.55 (0.09)**	0.58 (0.07)**	0.61 (0.08)**	0.56 (0.07)**	0.44 (0.07)**
Efficacy (COVID-19) t2	0.23 (0.08)*	0.15 (0.10)	0.21 (0.11)	0.25 (0.08)**	0.25 (0.08)**
Similarity of action t2	0.07 (0.07)	0.08 (0.07)	−0.04 (0.08)	0.12 (0.07)	−0.03 (0.09)
Interaction efficacy (COVID-19) × similarity of action	−0.017 (0.08)	0.23 (0.11)*	0.18 (0.14)	−0.06 (0.07)	0.13 (0.10)
R^2	0.40	0.48	0.45	0.49	0.35
F (df1 = 4/df2 = 108)	18.17**	25.21**	22.25**	25.69**	14.25**

*p < 0.05, **p <0.01. n = 113. Unstandardized regression coefficients b with standard errors (SE) in parentheses.

Among those who are average in similarity of threat (because of mean-centering), an increase in COVID-19-related self-efficacy by one step leads to an increase in climate-related self-efficacy at t2 by 0.19 steps ($b = 0.19^*$). This indicates a direct transfer of efficacy beliefs. Vice versa, among those who are average in COVID-19-related self-efficacy, an increase in similarity of threat by one step leads to an increase in climate-related self-efficacy at t2 by 0.16 steps ($b = 0.16^*$). This indicates that the COVID-19 crisis raised awareness of the role everyone has to play in reaching a common goal. The interaction term in this example is not statistically significant.

We first present the results pertaining to the transfer of efficacy beliefs from the pandemic to the climate crisis. As in Study 1, we find a unique, statistically significant direct transfer effect of COVID-19-related self-efficacy onto its climate-related self-efficacy counterpart ($b = 0.19^*$ and $b = 0.23^*$, in Tables 3, 4, respectively), above and beyond the stability of climate-related efficacy between t1 and t2. The same unique direct transfer effect between the two crises is found for positive ($b = 0.29/0.25^{**}$) and negative efficacy affect ($b = 0.24/0.25^{**}$). Unlike in study 1, however, direct transfer of participatory efficacy is not statistically confirmed (it is fully moderated by similarity of action though; see below). Direct transfer is also not statistically significant in collective efficacy. Throughout, all five climate-related efficacy beliefs show high stability over the course of three months from t1 to t2. Both stability and direct transfer effects are fairly constant in size across the various efficacy beliefs; direct transfer amounts to about a third to a half of the stability effects (coefficients ranging ca. $b = 0.50$ to $b = 0.60$ in stability; ca. $b = 0.20$ to $b = 0.25$ in direct transfer).

Second, we are interested in the role of perceived similarity between the two crises. As shown in Table 3, similarity of threat is positively associated with self-efficacy ($b = 0.16^*$), participatory efficacy ($b = 0.31^*$) and positive efficacy affect ($b = 0.22^*$). This effect tends to be slightly weaker than the direct transfer of efficacy beliefs. Contrary to assumptions, no statistically significant interaction of similarity of threat and COVID-related efficacy beliefs on the climate-related counterparts is found. As shown in Table 4, similarity of action is not associated with any climate-related efficacy beliefs; however, similarity of action moderates the transfer of participatory efficacy (interaction $b = 0.23^*$). Here, for each step of similarity of action on the five-step response

scale, the effect of COVID-19-related participatory efficacy on climate-related participatory efficacy at t2 is additionally increased by.23 steps. The unique simple effect of COVID-19-related participatory efficacy is not statistically significant ($b = 0.15^{n.s.}$); thus, the influence of COVID-19-related participatory efficacy fully depends on similarity of action. This indicates that the learning of participatory efficacy beliefs requires a perceived similar context of the COVID-19 and the climate crisis.

Discussion

Despite its small sample size, and in line with our first research question, Study 2 confirms the transfer of self-efficacy beliefs from the COVID-19 to the climate crisis found in Study 1, and additionally finds transfer of efficacy affect between both crises. Contrary to Study 1, however, the transfer assumption of the first research question was neither supported for participatory efficacy, nor for collective efficacy. When comparing the sizes of the unstandardized regression coefficients across all results of Study 2, the direct impacts of COVID-19-related efficacy and similarity are about a third to a half of the stability of climate-related efficacy. This suggests that efficacy beliefs are indeed changeable and fluid – presumably because the exceptional disruption of the national lockdown provided almost daily action-oriented feedback on the perceived capability of coping with an existential crisis. Regarding our second research question, similarity as a favorable condition for the transfer of efficacy beliefs is only confirmed as a significant interaction between similarity of action and participatory efficacy.

Study 2 comes with important methodological caveats: The findings only apply to Austrian high school graduates and need to be replicated for other countries and other populations. The small sample lacks statistical power to confirm more subtle transfer or moderator effects. Efficacy beliefs were assessed with regard to the overarching goals of climate protection or tackling the COVID-19 crisis; this may attenuate the relevance of the results for specific everyday actions (Lauren et al., 2019). Similarity of threat and similarity of action are derived *post-hoc* from exploratory factor analysis and need not generalize to the communalities between other contexts where transfer may occur. Finally, participatory and collective efficacy named other (young) people as in-group, but the social identity of belonging to this group was not emphasized to the respondents before measuring those efficacy beliefs. Thus, lack of salient group identification could be an alternative explanation for the absent transfer of participatory and collective efficacy from COVID-19 to the climate crisis.

General discussion

Using the research opportunity to collect survey data when the first COVID-19 lockdown ended in Switzerland and Austria, the present paper explores the transfer of efficacy beliefs from the COVID-19 pandemic to the climate crisis. We find empirical support for our first research question, that COVID-19-related efficacy beliefs directly affect their respective climate-related counterparts, even when controlling for climate-related self-identity or the stability of climate-related efficacy beliefs over time. Our results from samples of two different countries thus support corresponding theoretical assumptions expressed at the beginning of the pandemic (Reese et al., 2020; Lehmann et al., 2021), and extend previous empirical evidence on possible efficacy transfer (Lucarelli et al., 2020; Meijers et al., 2021).

Our results are less clear regarding our second research question on the mechanisms, conditions, and behavioral effects of this efficacy transfer. We find evidence of partial mediation of the effect of COVID-19-related efficacy on private behavior and policy support *via* climate-related efficacy, and of a moderator effect of perceived similarity. These findings do not emerge consistently across the two samples and five efficacy beliefs tested, however. We therefore return to the processes outlined in the introductory sections of this paper on how a transfer from the COVID-19 pandemic to the climate crisis might unfold.

First, the *efficacy transfer process* from the COVID-19 pandemic to the climate crisis appears more robust for self-centered efficacy beliefs, that is to say, self-efficacy and efficacy affect. Transfer of self-efficacy is confirmed in both Study 1 and Study 2; Study 2 additionally finds transfer of positive and negative efficacy affect. By contrast, group-centered beliefs, in other words, participatory and collective efficacy, only turn out to be significant in Study 1. This lack of participatory and collective efficacy transfer may trace back to the absence of collective activities due to the very nature of the lockdown, which prevented students from experiencing collective functioning with their peers (apart from virtual interaction). By contrast, the positive association between COVID-19- and climate-related participatory efficacy in Study 1 may stem from its mostly adult sample who had more opportunities for experiencing successful (that is, pandemic-preventing) collaboration, for example, at their workplace or when caring for their elderly relatives. If, however, the restriction of efficacy transfer to self-centered beliefs as observed in Study 2 is confirmed in future studies using larger, more representative samples, this contradicts Reese et al.'s (2020) optimistic expectation that group processes during the COVID-19 crisis might inform collective appraisal and action regarding the climate crisis.

Second, the effects of COVID-19-related efficacy beliefs on climate-related behavior responses in Study 1 are partially, but not fully mediated by climate-related efficacy beliefs. Thus, our results support previous research on efficacy beliefs as

spillover mechanism (e.g., Lauren et al., 2016; Nilsson et al., 2017; Carrico, 2021). It seems that efficacy beliefs play an additional, directly predicting role besides functioning as an indirect, mediating mechanism. Possibly, the unique direct effect on private behavior and policy support stands for a *consistency process* of people striving to uphold a self-image as a conscientious citizen who cares for societal problems. Future studies should thus control for confounding factors which may govern or even distort the relationship between efficacy beliefs and behaviors. Possible confounding factors are, for example, a strong identification with all humanity (Reese et al., 2015), or a strong internal locus of control (Fielding and Head, 2012; Engqvist Jonsson and Nilsson, 2014), but might also encompass attitudinal or trait characteristics, such as e.g., trust in science or high optimism, that might explain both, climate- and COVID-19-related efficacy beliefs. Future studies should include and control for such potential confounding variables. Finally, our results suggest that self-identity also acts as a confounder and needs to be considered in future studies. The exact interplay of self-identity and self-efficacy could not be elucidated in detail in this study. In our view, it should therefore definitely be the subject of future studies.

Third, a perceived similarity of threat between the two crises does not moderate but directly predicts climate-related efficacy beliefs in Study 2. Perceiving both crises similarly as threats seems to advance a *process of raising awareness of the personal role* in managing the climate crisis. Realizing both COVID-19 and climate as pressing crises that call for extensive collaborative efforts increases climate-related self-efficacy, a positive outlook of feeling hopeful and motivated, and, most pronounced, participatory efficacy. This resonates with previous research that perceiving the climate crisis an urgent and important issue increases self-efficacy (Tabernero and Hernández, 2011) and that the COVID-19 pandemic and the climate crisis are perceived as similar threats (Bostrom et al., 2020; Geiger et al., 2021b). Consistent with a potential awareness-raising function of similarity of threat, we do not find any significant influence of similarity of action on efficacy beliefs: Similarity of action refers to short-term and governmental intervention and so does not highlight the role oneself could or should play.

Fourth, and finally, the interaction effect of similarity of action on participatory efficacy, as found in Study 2, points to an efficacy-building *process of learning from similar contexts*. When recognizing as a communality between both crises that state action yields short-term remedies, confidence in one's incremental yet crucial contribution as a member of the collective is transferred from the COVID-19 to the climate context. Lucarelli et al. (2020) report a similar process where considering the COVID-19 and the climate crisis as interdependent builds self-efficacy; however, we find a statistically significant interaction term only for participatory efficacy, in sharp contrast to efficacy theory that underscores learning and applying skills to other, similar contexts as the principal avenue for developing various efficacy beliefs (Bandura, 1977). It seems that learning from similar contexts plays a marginal role in building efficacy beliefs compared to the processes of transfer and awareness-raising, as described above. Presumably, the COVID-19 crisis rather activated or made more salient pre-existing climate efficacy beliefs instead of actual learning and formation of new beliefs taking place.

The *ad hoc* data collection in spring of 2020 was, on the one hand, an exceptional research opportunity but is, on the other hand, a central limitation of the present study. As the pandemic has since progressed through subsequent infection waves triggering repeated lockdowns, the results only offer a snapshot from the initial phase of the pandemic. Possibly, as individuals and collectives struggle(d) in coming to terms with a persistent crisis during the later and current phases, the transfer of efficacy beliefs may have changed because people had varying experiences of mastery and performance accomplishment. It also remains a topic for future research whether transfer from one crisis to the other occurs not just within the same efficacy belief (e.g., from COVID-19- to climate-related self-efficacy, as investigated in the present study), but also between different efficacy beliefs (e.g., from COVID-19-related self-efficacy to climate-related collective efficacy). Both aspects require longitudinal data with larger samples and more survey waves than available for this paper. When Study 2 participants were contacted a third time in April 2021, the sample size dropped to just $n = 68$ respondents which is why we did not include a third measurement point t3 in our longitudinal analysis.

Conclusions

When the COVID-19 pandemic forced governments to implement swift and radical measures, many voices argued that this might provide a blueprint and door opener for ambitious climate action once the pandemic declined (e.g., Reese et al., 2020; Lehmann et al., 2021). Developing an individual and collective sense of capability to achieve a common goal, be it overcoming the pandemic or reaching the 1.5°C climate target, could be one of the many possible lessons humanity may take from COVID-19. Our results suggest that if the lockdown in the spring of 2020 was experienced as a successful strategy of crisis management, efficacy beliefs for combating climate change increased. Efficacy beliefs are hard to increase in laboratory environments (Hamann and Reese, 2020), and it seems to take substantial interventions to change ingrained beliefs such as a coaching weekend program (Hamann et al., 2021) or even a pandemic lockdown. The regression coefficients observed in our studies are rather small in magnitude, though, so we do not expect massive turnarounds in consumer lifestyles and climate policy acceptance. Moreover, most transfer effects found encompass self-centered efficacy beliefs, so we assume that

the pandemic triggers individual rather than collective climate action. Last but not least, it should be kept in mind that transfer functions in both ways – experiences of success may carry over to other contexts as well as experiences of failure, as indicated by the positive sign of our regression coefficients.

Since our data collection after the first COVID-19 infection wave, the world has seen several successive waves. The initially optimistic public debate was replaced by public criticism of restrictive governmental measures. Social trust and public acceptance of the measures have declined (Siegrist and Bearth, 2021). It became apparent that the GHG reductions resulting from the pandemic only marginally contribute to climate targets (Meles et al., 2020). These positive effects on the climate went along with massive costs for welfare and the economy (Elliott et al., 2020; Foad et al., 2021). We may only speculate how individual and societal efficacy transfer processes from COVID-19 have been continuing beyond the timeframe of our fieldwork. Monitoring the development with longitudinal studies would be indispensable to obtain greater clarity. Several parallel processes might have been shaping how efficacy beliefs evolve(d) over the course of the pandemic: A (further) decrease in public acceptance of radical governmental measures could undermine perceived collective efficacy to combat climate change. As the immediate COVID-19 threat fades into the background, the experiences and lessons gained from the pandemic might, as well, and climate-related efficacy beliefs could fall back to pre-pandemic levels. Or, contrariwise, as COVID-19 becomes a less pressing concern, citizens might (again) become more willing to engage with comprehensive state action for protecting the climate, following the finite pool of worries approach (Evensen et al., 2021).

It already seems undisputed that the radical measures taken in the pandemic cannot serve as a blueprint for dealing with the climate crisis; the social and economic costs have been far too high. A careful reappraisal and evaluation of our coping with the COVID-19 crisis in order to draw appropriate lessons are imperative (Howarth et al., 2020). As our results suggest, however, emphasizing the successful management of the COVID-19 crisis will most likely build public confidence that we can combat other global crises, such as the climate crisis, as well.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

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The remaining author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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The other blue: Role of sky in the perception of nature

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Nature is frequently operationalized as greenery or water to estimate the restorativeness of the environment. Pursuing a deeper understanding of the connection between representation of naturalness and its relationship with restoration, we conducted an experiment aimed to investigate if the sky is perceived as an element of nature. The main goal of this study was to understand how the composition of the environment guides people's selection of sky as nature in an explicit task. Moreover, we investigated how the amount of visible sky determines this relationship. One hundred five participants participated in a novel explicit judgment task conducted online. In this task, we prepared a set of images trimmed out of 360-degree high dynamic range images. The images were classified according to two primary independent variables representing type of environment (four levels: Nature, Some Nature, Some Urban and Urban) and horizon level (three levels: Low, Medium and High). Each participant was asked to select, by clicking on the image, what they consider as "nature." In addition, they were asked to judge images on five visual analogue scales: emotional response, aesthetic preference, feeling of familiarity, the openness of the space and naturalness. For analysis, images were segmented into 11 semantic categories (e.g., trees, sky, and water) with each pixel being assigned one semantic label. Our results show that, sky is associated with selections of nature in a specific pattern. The relationship is dependent on the particular set of conditions that are present in the environment (i.e., weather, season of the year) rather than the type of the environment (urban, nature). The availability of sky on the image affects the selection of other nature labels with selections more likely when only a small amount of sky was available. Furthermore, we found that the amount of sky had a significant positive association with the naturalness rating of the whole image, but the effect was small. Our results also indicate that subjective selections of sky predict the naturalness better than trees and water. On the other hand, objective presence of trees and water has a stronger positive association with naturalness while objective presence of sky is positively associated with naturalness. The results show that, relative to its availability sky is considered as nature.

KEYWORDS

sky, greenspaces, environment, nature, GLMM, urban and naturalness

Introduction

Within the process of global urbanization, the population is moving away from natural environments into man-made urban centers (Mac Kerron and Mourato, 2013; Pelgrims et al., 2021; Mouratidis, 2022). In the coming decades, the population will continue to concentrate in urban areas (Ritchie and Roser, 2018). That shift in habitats stimulates growing academic interest in its implications for population health. A major line of research is the identification of the salutogenic factors of living environments for the purpose of informing future policymaking and supporting global population wellbeing.

Part of the discipline of environmental psychology is focused on unravelling the core principles of the beneficial effects of nature on psychological wellbeing. The theoretical narrative has built its assumptions around the principle of the restoration of depleted adaptive resources. Two theories about processes through which people benefit from non-threatening nature underlie most of the current evidence. (1) Stress reduction theory (SRT) (Ulrich et al., 1991) assumes that access to nature benefits emotional restoration and helps offset the effects of stress. (2) Attention restoration theory (ART) (Kaplan and Kaplan, 1989) posits that natural environments aid in recovery from mental fatigue, in particular, attentional capacity. Since then, an extensive body of evidence has shown different effects of nature on the mind and brain. Currently, evidence suggests the beneficial effects of nature on improved attentional capacities (Berman et al., 2012), stress recovery (Valtchanov and Ellard, 2015), anxiety, and depression (Kotera et al., 2021). Recently, these investigations extended into the neuroscientific domain (Bratman et al., 2015; Kühn et al., 2017). Research on the effect of a casual walk in the forest on the amygdala, which has been linked to stress processing (Sudimac et al., 2022), indicates that amygdala activation decreases after a walk in nature, whereas it remains stable after a walk in an urban environment. Thereby the result suggests an explanation for the salutogenic effect of nature on brain functional physiology.

Green and blue spaces have long been investigated as sources of beneficial effects of nature (White et al., 2021). Green spaces refer primarily to parks, forests and other predominantly vegetated areas. So-called "blue spaces" traditionally refer to water bodies: rivers, ponds, lakes etc. Such interpretation resulted in research prevalently measuring the effect of nature as conveyed by these studied components (e.g., trees, lakes). The study by Berto (2005) used pictures of green and blue spaces (trees and water) and found that exposure to these restorative features would improve attentional capacity. In the experiment by Berman et al. (2008), participants were sent on a predefined, one-hour walk in an arboretum with a path specified within green spaces. The effect on attention restoration was compared to the effect of a walk on a busy urban road. The arboretum walk was found to substantially improve working memory performance. In a larger-scale study (Dadvand et al., 2015), green space in the direct neighborhood was associated with cognitive development among schoolchildren.

To better account for global environmental diversity, the research has recently more extensively explored the "blue" surface: namely water. In an interesting review of the cross-disciplinary evidence on the subject, White et al. (2020) outlined the notable differences between green and blue space effects on health and wellbeing outcomes. The reviewed evidence revealed a wide array of relationships between diverse interactions with blue spaces and lower risks to mental health. What has been rather in the background of scientific focus so far is that nature has one more significant "blue": the sky.

The sky is a space and surface that lies above the horizon and the surface of the Earth. The sky's physical properties have a contextual impact on how the environment is perceived. An example of such an effect is the influence of the spectral frequency of light and color and change the physical conditions and visual properties of the environment (sunshine, rain, snow, and sand). Spatially, sky delimits the view on the horizon forming the skyline, aiding in shaping the perception of scenes' depth and openness of the view. Visually, sky generates a sense of a physical barrier, encircling the environment from each of the three-dimensional directions. Therefore, it is reasonable to assume the sky has a significant potential to influence the environment (Li and Du, 2021). Consequently, it holds the capacity of arbitrating the effects of nature on mental health. Since nature and sky exposure are frequently concurrent, Beute and de Kort (2013) pursued the investigation of the parallel effect of naturalness and daylight to find that there is explicit preference for bright, sunny, and natural scenes. The assumption of interaction between sky, view and environment is at the core of the recent extensive review by Beute (2022) who gathered compelling evidence of beneficial characteristics of window views, connecting the properties of daylight, views, and windows. In the review, several studies referred to the latent effect of sky and its condition. They indicated mixed outcome on the measured effect (notably preferences and restorativeness) with some evidence indicating no effect of sky on wellbeing or higher satisfaction with the views. In these studies, sky is conceptualized as an integral part of the window views and hence investigated as part of the overall effect. The review points out that frequently used outcome measures assess subjective wellbeing, preference and broadly defined restorativeness. In the 2018 experiment Masoudinejad and Hartig (2018) investigated how much sky and other components of the scenes in images affect expectations that urban window view will have a restorative effect. The result showed that views with increased visibility of sky were judged as the most restorative. Later, in a virtual reality study of window view effect Masoudinejad and Hartig (2018) showed that visibility of the sky was positively related to emotional restorativeness. Interestingly, no effect of weather type was found. An openness of the space study by Raanaas et al. (2011) showed that an unobstructed window view of natural surroundings supports clinical rehabilitation. Using a different approach of direct exposure rather than window view Asgarzadeh et al. (2014) showed that sky visibility improves the perception of spaciousness. In their investigation of the relationship between gaze patterns and view

preference Batool et al. (2021) observed that while verbally describing the preferred view, participants indicated importance of sky and patterns visible on it to their preference scene.

Further strengthening the importance of including the sky in environmental psychology research comes from work on seasonal affective disorder (SAD). SAD is now clinically classified as a major depressive disorder (Diagnostic and statistical manual of mental disorders: DSM-5™, 2013). The disorder is widely associated with reduced availability of natural light during the winter months and decreased outdoor activity, a phenomenon that could likewise be connected to sky exposure (Sarran et al., 2017; Fonte and Coutinho, 2021). However, overall "the other blue" – the sky has attracted little direct attention in comparison to vegetation and water.

The evidence so far arbitrarily assumed that sky is an expression of naturalness as a part of visual world. To what extent people actually perceive the sky as part of nature is unknown. This gap in the empirical evidence concerning the sky seems to be substantial but depends on a significant factor. So far, the intention of experimental methodologies is to assemble the stimulus set (as images, videos, or walks) that expresses the naturalness of the environment through the perspective of particular landscape characteristics. As a result experiments investigate the effect through the lens of specific landscape features, i.e., tree density, coverage of green spaces, or water bodies. Berto (2005) explicitly mentions the representation of trees or sea as guiding the image selection. In their study of the influence of naturalness on expressed thoughts, Schertz and Berman (2019) assembled park pictures that convey specific ground layout patterns aimed at capturing involuntary attention through soft fascination. While investigating the effect of walking in nature on neural activity in the prefrontal cortex, Bratman et al. (2015) designed the walk in nature based on an understanding of the natural environment as an urban greenspace composed of grassland, woodland, and wide ocean view. The studies discussed by Beute (2022) that indeed incorporated sky into designs, did so while considering sky as a secondary component separate from landscape in the overall window view or scene. In essence, sky is neither considered "green" nor "blue." Yet, the effect is most likely latently present in the measured outcomes. There is considerable scholarship showing the positive influence of viewing images of nature with the effect driven in a bottom-up manner by effects of low-level image statistics (Berman et al., 2014; Kardan et al., 2015; Ibarra et al., 2017). However, these studies approach the view of a scene as entirely natural or urban, globalizing the effect of image statistics, without further separating the context. The interaction between the low-and high-level visual processing is well-evidenced to be highly interactive (Groen et al., 2017). Hence the assumption of combined effect of image statistics and category content on how people perceive nature is most likely. However, none of the studies in environmental psychology so far explicitly investigated it. In this paper, we focus on bringing the sky into the framework of nature perception while investigating the content context inside the scenes. Potential interactions with low-level visual features falls outside of scope of this paper.

Our objective is to begin to close the above-mentioned gap in environmental psychological research by explicitly investigating the role of the sky in the perception of nature. We aim to overcome the empirical ambiguity in the research by directly studying the effect of the perceived amount of sky and its conditions. In the current paper, we present our investigation showing that the presence of sky in diverse environmental contexts and different amounts impacts participants' choices on what they would refer to as "nature." We expect these decisions to affect their judgment of naturalness. For our research, we defined naturalness as formed by the properties of the environment, scene or object, which are either present or mimic the properties of the organic world. To operationalize our assumption we designed a novel paradigm in which we combined a free-selection task with the subjective judgment of images containing outdoor scenes. Our methodology allowed participants to explicitly select what they considered "nature" on images. The scenes represent types of environment, varying levels of horizon, weather conditions and seasons of the year. Unlike the previous research, analyzing the sky as a component of window view (Beute and de Kort, 2013), which frequently focused on categorizing environments as urban or nature, our design accounts for diversity of circumstances where these two categories overlap and interact. Such an approach follows the suggestion of Hartig (2021) who argues that from a social and behavioural point of view, humans in cities perpetuate the same natural processes as in other habitats. In order to more accurately control for the amount of sky and sky conditions we have manipulated the horizon level in the scenes and accounted for common weather patterns affecting the view. We measured how frequently the sky was chosen as an element of nature, in what quantities and context. The resulting nature-selections were expressed in quantitative (i.e., number of selections, sky selections) and qualitative measures (semantic vector of features selected). Moreover, for each image, we also collected subjective judgments of aesthetic preference, feeling of openness of the space, perceived naturalness, and invoked emotional response (stress-relaxation dimension). Consequently, the study models the direct relationship between sky, environment, and individuals' internal representation of nature in distinct contexts.

Materials and methods

Participants

The study was approved by the Local Psychological Ethics Committee at the Center for Psychosocial Medicine (LPEK-0280) at University Medical Center Hamburg-Eppendorf, Germany. Our study recruited a sample of 113 healthy participants *via* the experimental platform Prolific in the United Kingdom. The size of required sample was established by power calculation performed in WebPower (Zhang and Yuan, 2018) with expected medium

effect size of 0.4. The data obtained in the study were carefully inspected for irregularities. Data from two participants were excluded due to failure to complete the task. Additionally, we excluded six participants because their answers to the socioeconomic status questionnaire were not recorded due to a technical error. In total, eight participants were excluded from further analysis. Out of 105 participants included in the final analysis 51 were females ($M_{age} = 27.6$, $SD_{age} = 7.38$) and 54 were males ($M_{age} = 27.5$, $SD_{age} = 8.08$). All participants were required to have access to a screen size between 13″ and 20″. The inclusion criteria also included the absence of a history of neurological and psychological disorders and traumatic brain injury. Data collection was performed online in July 2021 in the United Kingdom, during the coronavirus pandemic, however outside of the period of extensive and prolonged country-wide lockdown. Nevertheless, the authors would like to highlight that the outcome of the study may be affected by these circumstances affecting the participants responses. Out of 113 participants 49 declared that they were currently working from home and declared that they have been working from home for an average of 12 months ($SD_{WFH} = 7$). Due to the pandemic restricting the movement we have also collected data on the associated time spent outdoors. Participants working from home spend daily on average 2 h 30 min outdoors ($SD_{outdoor} = 1.45$) while participants not working from home spend on average 4 h 15 min outdoors ($SD_{outdoor} = 2.90$).

Stimuli

The images used in the experiment were created from selected 48 High Dynamic Range Images (HDRI)—a 360-degree hemispherical images sourced from the HDRI database HDRIheaven.[1] Each HDRI had to fulfil the following criteria: no visible people in the foreground, no landmarks, visible sky, minimal banners or text and minimum 8 k quality. The HDRIs were chosen from a database using a metasearch engine with keywords: "nature" and "urban." Three independent evaluators classified the selected images into four categories: urban, some urban, some nature and nature. These categories reflect the levels of primary independent variable. Each category contains an equal number of 12 HDRI environments. We defined environmental categories as follows:

- (U)Urban: A landscape strongly dominated by the presence of man-made structures with few to no natural elements.
- (SU)Some urban: A landscape with mostly man-made structures but including some natural elements.
- (SN)Some nature: A landscape where natural elements have a significant presence, including some man-made structures.
- (N)Nature: A landscape with a complete absence of human alterations and structures.

Additionally, the image set accounted for covariates of diverse weather conditions and seasons of the year. Finally, out of each HDRI environment, 6 image trims were taken using Adobe Photoshop 2021 3D Spherical Panorama tool[2] (see Figure 1A for an example). Six trims corresponded with the following 2 vantage point conditions creating two image triplets per environment: front image (0-degree camera rotation), back image (roughly 180-degree camera rotation); and 3 horizon location conditions: low horizon, medium horizon and high horizon. These conditions correspond with the level at which the horizon was present on the trimmed image. Control of vantage point was added during the stimulus set preparation to assure the control for the within-HDRI environment variance of the view. As a result of trimming, a total of 288 images were created and resized to 1500 × 750 pixels with 72 pixels/inch of resolution.

Following trimming, all 288 images were then semantically segmented into the following categories of interest: trees, sky, grass, water, rocks, sand, vegetation, snow, manmade, and background (used for unclassified or blurred pixels). Categories were found to be most common occurring to the environments included in the experimental image set. The segmentation was performed using LabelMe, an open-source annotation tool (Wada, 2016). The resulting annotation matrix was converted into a semantic vector by quantification of the surface of each semantic label on the image (i.e., the percentage of the surface taken by sky on the image). Such an approach allowed us to identify the semantic vector of choices made by participants. Additionally, the final image set was annotated with a categorical vector representing weather conditions in the sky: clear, grey, and cloudy; and seasons: winter, autumn, spring, and summer.

As the last step, based on semantic segmentation of the images we have created additional covariates: percentage of the sky on the image, percentage of nature (quantified percentage of surface covered by semantic labels associated with natural environments), total percentage of greenery (grass + trees + vegetation).

Design

In order to obtain the subjective evaluation of the images, we conducted a 4 × 3 × 2 factorial mixed-design experiment that used a randomized subset of 96 images (out of 288). The manipulated independent variables within the image set are the type of environment (U,SU,SN,N – levels described above),

1 https://polyhaven.com/hdris previously https://hdrihaven.com/hdris accessed 10/12/2020.

2 https://helpx.adobe.com/photoshop/using/create-panoramic-images-photomerge.html

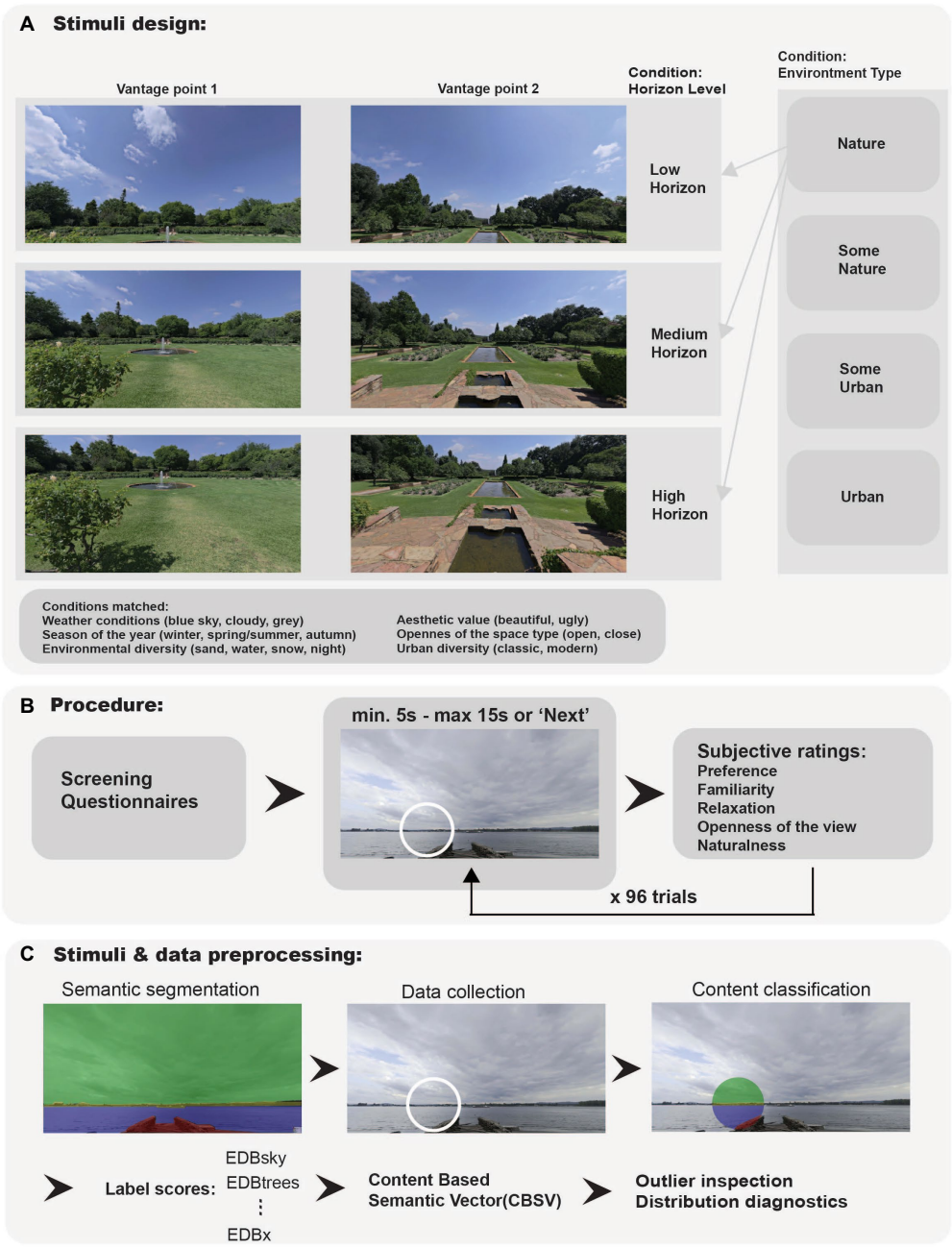

FIGURE 1
(A) Stimuli design. **(B)** Procedure. **(C)** Stimuli and data pre-processing.

horizon level (Low, Medium and High) and vantage point (front, back) within the original HDRI environment. The key variables are described in detail in the previous section (Stimuli). However, each participant saw only one horizon condition per image representing each vantage point (see Figure 1A). The variance in horizon condition was introduced to ensure that participants will remain unaware of the experimental manipulation and to increase the paradigms' internal validity. In consequence, the presented image set differed for each participant. Therefore, in the analysis, we introduced participant and image as having a random effect on the outcome.

Subjective rating scales

As a part of the experimental procedure, we have asked participants to rate the images on five subjective scales. Each scale assessed a different aspect of response evoked by the image. First, we asked for aesthetic preference dislike – like

commonly used in experimental designs investigating environmental effect. We also asked how familiar the scene was to the participant unfamiliar – familiar. We asked participants to rate the feeling of emotional response to the image—whether it made them feel more stressed or relaxed. The scale followed the theoretical assumptions of ART assuming the natural environments are found more restorative. Furthermore, we asked participants to subjectively judge the openness of the view (closed view – open view). Finally, we have asked participants to judge naturalness of the scene. With the exception of naturalness, all ratings were judged on the scale from −50 to 50 with default set of the cursor on 0. In the case of naturalness, we have asked participants to judge it on the scale 0 to 100, with 0 indicating no naturalness and 100 indicating full naturalness. Contrary to insofar approaches, we chose not to use artificial-natural binomial scale. We chose not to focus participants on assessment of manmade elements of the scene but instead asked them to assess the quality of its natural characteristics forming the perception of naturalness.

Questionnaires

As a part of the project, we have also collected a set of covariates in the form of well-established scales and questionnaires as well as a set of information about participant's environmental living conditions. A full list of collected items is available in the Supplementary material: List of covariates. Apart from standard demographical questions, we have used a personality questionnaire 10 item big five questionnaire (BFI-10; Rammstedt and John, 2007), a state and trait anxiety inventory (STAI; Spielberger et al., 1983), aesthetic responsiveness assessment scale (AREA; Schlotz et al., 2020), and connectedness to nature scale (CNS; Mayer and Frantz, 2004). As a part of the questionnaire, we have also asked questions living conditions during upbringing [based on urbanicity score by Lederbogen et al. (2011)], current living conditions, whether they work from home at the moment and if so, for how long. Moreover, we have asked participants to name three words that came to their mind, associated with the word "nature" and "urban." These covariates are not the focus of this particular analysis. Therefore, they are not part of the paper.

Procedure

The experiment was delivered online using the Prolific testing platform with a paradigm programmed in Java Script (Czienskowski, 2021). After the initial screening for exclusion criteria, participants were first asked to answer questions about their socio-economic status, living conditions, STAI, BFI-10, AREA, and CNS questionnaires. Afterward, in a novel free-selection task participants were presented with each of the 48 environments from two different vantage points, answering 96 randomized image trials in total. Each participant saw 8 images from each of the 12 conditions (3 horizon level × 4 nature category) in randomized order (Figure 1B).

For each image trial, the task was to select areas on the images that participants considered nature. The selection was made with a circle frame of a 150-pixel radius that was operated with a computer mouse or touchpad. Participants had 15 s to answer and an unlimited number of selections. However, they could not move on to the next image during the first 5 s. After 15 s or when participants clicked on the "Next" button, the application proceeded to the evaluation. Here participants saw a smaller version of the image with scales depicted below and were asked to subjectively evaluate the image based on five scales: familiarity, naturalness, the openness of the view, emotional response (feeling relaxed – stressed), and preference (Figure 1B). The trial sequence was repeated 94 times.

Data preprocessing

Preprocessing was performed in MATLAB 2020b (The MathWorks, Inc., Natick, Massachusetts, United States). Task-related data were preprocessed in two steps. First, we summed the number of clicks made by each participant on each image. These were inspected for outliers. All values above 20 were removed as well as indicated extreme behaviors (rapid, serial clicking in one area) that were not in line with the task. By extension, we investigated if these occurrences had patterns across specific subjects or images. Nevertheless, none of the participants or images was identified to cause the significant anomalies. Afterward, the selections made by participants were individually preprocessed using a content-based semantic logical classifier which compared the semantic content of each selection per click, image and participant with a previously semantically annotated file of the image (Figure 1C). The classifier calculated the content-based semantic vector (CBSV), which contained scores of relative total label selected (EDB) on the image. For each image, participant, click and semantic label the following score was computed:

$$\textbf{\textit{Score EDB}}_{\boldsymbol{x}} = \sum_n \left(\frac{D_x}{B_x} \right) \times 100$$

where, n is the number of the respective click, x a label, Dx total of pixels classified as label x within the selection circle and Bx is the total of pixels classified as label x in the image. Overall, the score is the expression of how much in total label x was selected by a participant on the image. Following the computation of EDB scores, the CBSV was inspected in a data quality check. We followed Zuur et al. (2010) description of the data preprocessing procedure. In CBSV, outliers across the labels expressed extreme behaviors. Such activity was detected in vectors of sky and rocks where participants' EDB indicated that they significantly exceeded the available surface of the label (serially

clicking in the same spot). The activity was limited to specific participants and images. Hence, we decided to remove only extreme activity or the entire image rather than the participant. As a result, the total number of images decreased to 258. In the case of the sky vector, we removed all values over 100 and absolute zeros. The latter resulted from experimental design. The cases where no selection was made resulted from the absence of sky (or very minimal presence <2%). It was the only vector where such elimination was performed due to its importance for the research question. For the resulting dataset ($n = 6{,}397$), we calculated the descriptive statistics for the semantic labels (see Supplementary material: Selection summary statistics).

In the case of subjective ratings, data diagnostic did not yield any outliers (Leys et al., 2013). However, there were many answers at the extreme points of the scales (for example, distribution, see Supplementary material: Distribution plots). We did not remove any of the extreme answers, since they were not statistical outliers. It seems that some participants may have treated the scales as binomial yes/no questions, although they were continuous.

Lastly, we have calculated the outcomes of covariate questionnaires: CNS, BFI, STAI, and urbanicity scores. However, these covariates are not the part of the analysis.

Data analysis

All statistical analyses were performed using R Statistical Software (v 4.1.2; R Core Team, 2022) and Python programming language (v 3.9; Python Software Foundation[3]). The list of packages necessary to reproduce the analysis is available in the Supplementary material: Package list.

The Kolmogorov–Smirnov (K-S) normality tests indicated that data did not conform to a normal distribution ($p < 0.001$) across the essential label sky and subjective ratings (Supplementary material: Distribution plots). Visual inspection revealed that our dependent variables were skewed: sky toward either lower values (selection scores) or binomially (ratings). Moreover, Levene's test indicated also a violation of homogeneity of variance ($p > 0.001$) across our experimental factors. Notably, both tests have decreased sensitivity to sample sizes bigger than 5,000. Consequently, we used robust methods to predict the effects of our experimental covariates.

Due to data normality violations, we have applied a non-parametric method to test the main free-selection task assumptions. The main study hypotheses required us to apply robust statistical modelling. Generalized linear mixed-effects models (GLMM) provided a solution to the violation of normality assumption across outcome variables, without the necessity to overly transform variables. GLMM enabled us to meet the mathematical criterion of normalized homoscedastic residuals in linear modelling. Transformation might have normalized the residuals but also distorted the ratio scale of measured variables. The GLMM approach allowed for differences between individuals to be properly assessed using metric context. Moreover, GLMM is capable of accounting for random populations that share nested relationships such as our experimental design. In GLMM analysis, we investigated the relationships between the subjective ratings and the amount of sky present in the images as well as the selection of sky as nature. In order to test if the design has the same impact on tree selection scores, we fitted an additional model with the obtained EDB scores of trees selection. Finally, we fitted the naturalness rating with GLMM models of tree and water selections with a random effect of the subject and image. A detailed description of GLMM computation is available in Supplementary material: GLMM computation.

3 https://www.python.org/

Results

Paradigm validation

To ensure our horizon categorization reflected the visibility of the sky, we checked if there were statistically significant differences between horizon level categories (Low, Middle and High) in the quantified percentage of sky coverage.

The one-way ANOVA indicated a statistically significant effect [$F(2{,}158.6) = 142.34$, $p < 0.001$ $\eta^2 = 0.500$] of the horizon level on the amount of sky in the images. Low horizon condition images on average contained 41.41% ($SD = 23.02$) of the sky surface, Medium 18.85% ($SD = 13.1$) and High 3.91% ($SD = 4.42$). *Post hoc* multiple comparison test with Bonferroni correction indicated significant differences ($p < 0.001$) between all levels of condition.

The non-parametric Kruskal–Wallis test explored the main free-selection task assumption that type of environment has an effect on the number of nature selections. The outcome indicates the statistically significant effect of the type of environment on the average number of nature selections [$H(3) = 212.18$, $p < 0.001$]. Dunn's *post hoc* multiple comparison test with Bonferroni correction additionally showed the difference is statistically significant ($p < 0.001$) among all environments with Nature ($M = 6$, $SD = 3$) and Some Nature ($M = 5$, $SD = 3$) conditions significantly higher than Urban ($M = 2$, $SD = 1.5$) and Some Urban ($M = 4$, $SD = 2$). We have also scrutinized the effect of the type of environment on ratings of naturalness. Here the Kruskal–Wallis test also showed a significant effect on the rating of naturalness [$H(3) = 2928.36$, $p < 0.001$]. Dunn's *post hoc* multiple comparison test with Bonferroni correction indicated significant differences in ratings among all conditions with the most substantial difference between Nature ($M = 84.86$, $SD = 18.61$) and Urban ($M = 26.05$, $SD = 24.32$) (Figure 2B). Moreover, Spearman rho indicated a strong positive correlation ($r = 0.787$, $p < 0.001$, see Figure 3) between the rating of naturalness and the objective amount of nature in the image. Overall, the results show that the main objectives of the free-selection task were met and participants performed the task

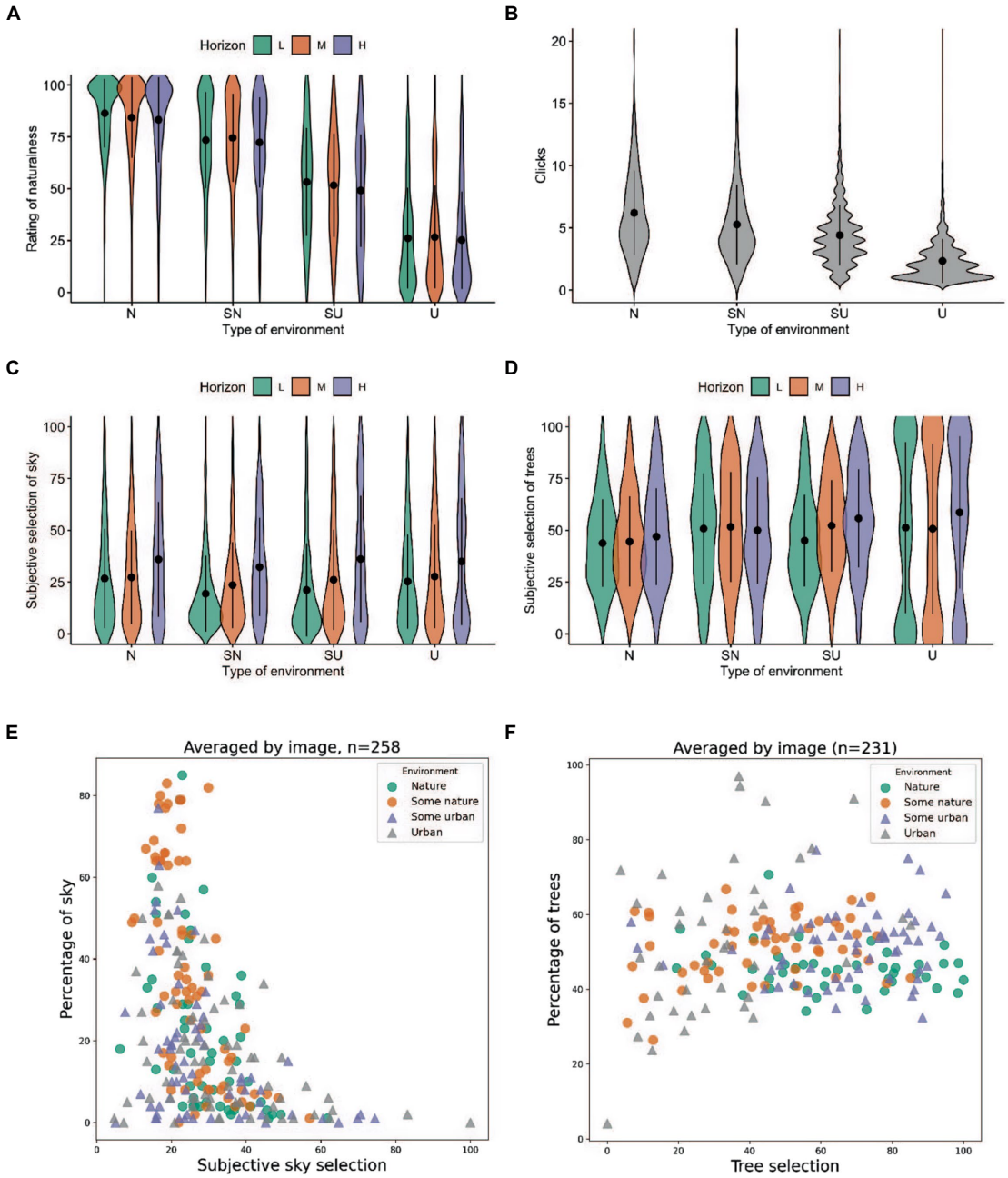

FIGURE 2
Results. **(A)** Distribution of ratings of naturalness over the experimental conditions type of environment and horizon level. **(B)** Distribution of number of clicks made in each type of environment. **(C)** Distribution of subjective selections of sky over experimental conditions. **(D)** Distribution of subjective selections of trees over experimental conditions. **(E)** Averaged over images, subjective selections of sky plotted against objective visibility of the sky. **(F)** Averaged over images, subjective selections of trees plotted against objective visibility of the sky. **(E,F)** Values are split by the types of environment.

as expected, making more selections in natural environments than in an urban context.

Sky in nature-selection context

We investigated how subjective selection of sky was connected to the selection of other semantic characteristics visible on the images. The overview (Table 1, for details see Supplementary material: Selection summary statistics) of the result shows that generally, the highest relative average selection rates were made on Vegetation ($M = 56$, $SD = 26$) and Water ($M = 53$, $SD = 27$). As expected, a lower selection rate was identified in Manmade label ($M = 29$, $SD = 23$), while the lowest selection rate was indicated by Sky ($M = 27$, $SD = 25$). The high standard deviation is understandable and indicated a large dispersal rate

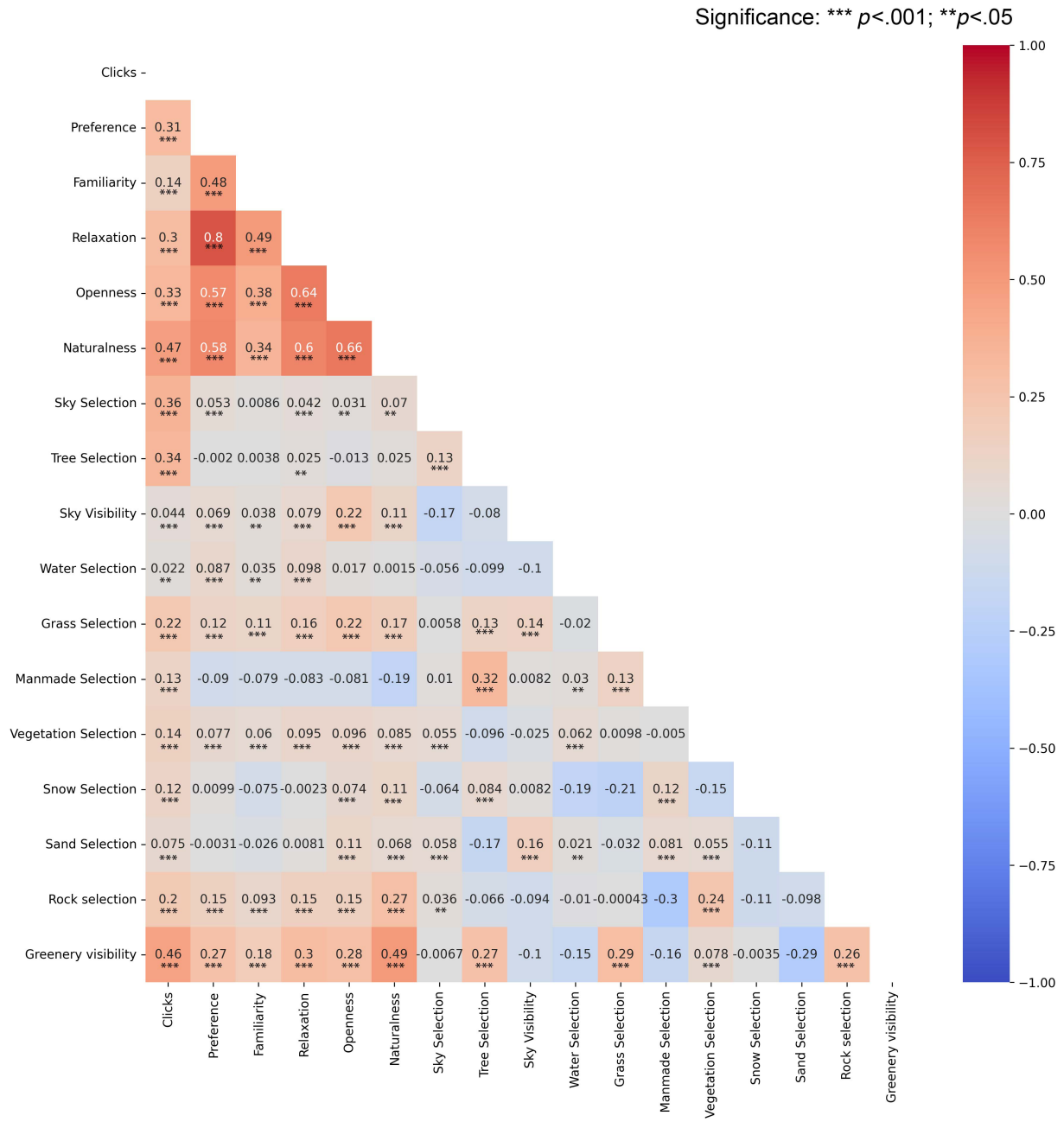

FIGURE 3
Pairwise correlation heat map.

between the scores hinted at during the normality diagnostics. Distribution across the experimental conditions shows a more comprehensive picture suggesting greater differences between the horizon level conditions.

Subjective ratings

We investigated the relationships between the key obtained variables: subjective ratings, objective measure of the sky, number of selections and selection of labels as nature (for summary statistics see Supplementary material: Subjective ratings summary statistics.). Figure 3 shows that the associations indicated significant ($p < 0.001$) moderate to strong positive relationships between all scales. The strongest relationship was detected between the preference rating and emotional restoration with $r = 0.796$ ($p < 0.001$) indicating that the participants were more likely to prefer images that invoked a stronger feeling of relaxation. The increased feeling of relaxation was also strongly correlated with the openness of the space ($r = 0.638$, $p < 0.001$) and higher

TABLE 1 Summary statistics of each label subjective selection (Score EDB).

	Sky	Trees	Water	Grass	Vegetation	Snow	Sand	Rocks	Manmade
Samples	6,397	5,070	950	1,261	616	547	362	357	854
Mean	27	50	53	52	56	39	37	44	29
Std.	25	28	27	38	26	25	23	24	23
Min	0	0	0	6	0	4	3	0	0
25%	7	29	33	29	36	20	19	26	12
50%	19	49	50	45	54	33	32	41	22
75%	41	70	73	69	74	51	52	60	40
Max.	100	100	100	776	100	164	100	100	100

The statistics were calculated based on the samples of pictures where the particular label was present.

naturalness ratings ($r = 0.600$, $p < 0.001$). We also found a strong positive association between higher naturalness ratings and preference ($r = 0.580$, $p < 0.001$) and a strong positive relationship between higher naturalness ratings and higher perception of the openness of the space ($r = 0.600$, $p < 0.001$). Rating of familiarity with the scene had a borderline strong positive association with an increased feeling of relaxation ($r = 0.495$, $p < 0.001$), moderate with a rating of openness ($r = 0.384$, $p < 0.000$) and a higher rating of naturalness ($r = 0.344$, $p < 0.001$).

Afterward, we investigated the relationship between the subjective ratings and the objective measure of the presence of sky and greenery. The increased visibility of the sky had a weak positive correlation with ratings of naturalness ($r = 0.113$, $p < 0.001$). On the other hand, the overall visibility of greenery had a borderline strong positive association with increased naturalness ratings ($r = 0.490$, $p < 0.001$). Interestingly, correlations also showed a comparable positive association between the objective amount of greenery and sky on an increased rating of openness of the space (greenery: $r = 0.278$, $p < 0.001$; sky: $r = 0.220$, $p < 0.001$). We also observed that the positive association with an increased feeling of relaxation is stronger for higher visibility of greenery ($r = 0.303$, $p < 0.001$) than the sky ($r = 0.079$, $p < 0.001$). The same pattern was observed in ratings of preference where higher preference ratings were moderately positively correlated with higher visibility of greenery ($r = 0.270$, $p < 0.001$) but we found no association with visibility of the sky ($r = 0.069$, $p < 0.001$).

Furthermore, we found a weak positive association between the subjective rating of naturalness and subjective selection (EDB scores) of key features: sky ($r = 0.070$, $p < 0.001$), trees ($r = 0.025$, $p < 0.05$), and water ($r = 0.001$, $p = 0.453$). Interestingly, at the same time, we found a significant moderate association between a higher number of clicks made on an image and higher sky selection ($r = 0.361$, $p < 0.001$) with a comparable pattern for higher tree selection ($r = 0.341$, $p < 0.001$).

Effect of environmental context on perception of sky as nature

To quantify how the selection of sky as nature is associated with the environmental context, we fitted GLMMs for subjective selection of the sky with a stepwise methodology. We assume that the perception of sky as nature depends on its visibility, context and state of the environment. In the initial model, we included the fixed effect of the type of environment as the main (first-level) experimental factor, with the random intercept of participant and image: $EDB_{sky} \sim environment + (1|participant) + (1|image)$. The plot of predicted values indicated that sky selections were more likely in natural and urban environments than in mixed (Figure 4A). However, the fitted model estimates indicated that the environment type alone did not significantly affect the selection of sky as nature ($p > 0.05$; see model table in Extended Data). Moreover, marginal R^2 at 0.004 shows that type of environment explains little variance within the model performance (conditional $R^2 = 0.534$). The alternative model extended the additive term for second-level experimental factor of horizon level ($EDB_{sky} \sim environment + horizon + (1|participant) + (1|image)$) to reflect the general experimental design. That factor was associated with the amount of sky present in the image and was presumed to impact the selection. The model's estimates revealed a statistically insignificant effect of types of environments ($p > 0.05$) but significant ($p < 0.001$) association for each horizon level (for details, see model table in Supplementary material: Extended data. GLMM Tables.). A notable difference was found between the Low horizon, and High horizon condition with sky selection significantly increased when the horizon level was high up in the image, so that the fewer sky was visible the more it was selected as nature (Figure 4A). The marginal $R^2 = 0.056$ indicated an increase in the explanatory value of the horizon as compared to that of the entire model (conditional $R^2_{alt} = 0.533$). The difference between baseline and alternative models was significant [$X^2(2) = 47$, $p < 0.001$]. The improved AIC indicator of the alternative model ($AIC_{null} = 53655.2$ vs. $AIC_{alt} = 53601.6$) reveals that the selection of sky as nature depends on more complex associations between variables. Furthermore, the horizon level plays a significant role in rating sky as nature.

Pursuing the relationship between the selection of sky and the horizon level, we reformulated the model regarding sky conditions. As a result, in the second set of models, the model dropped the type of environment as a fixed effect and included horizon level with a random intercept of participant and image name: $EDB_{sky} \sim horizon + (1|participant) + (1|image)$. Model estimates indicate a strong significant effect of all horizon levels

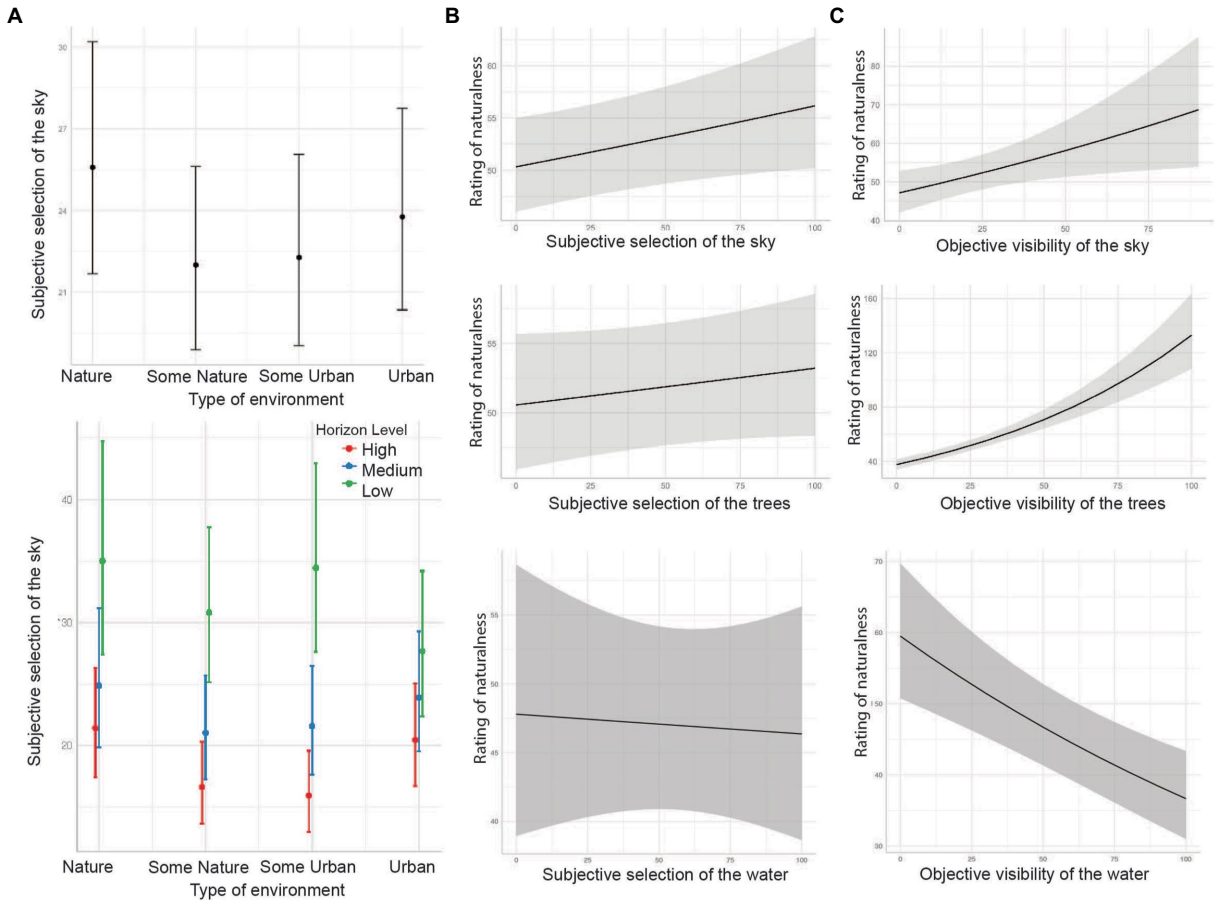

FIGURE 4
Results of the GLMMs. **(A)** Plot of predicted marginal effect of type of environment on subjective selection of the sky. Below, distribution of the effect by type of environment and horizon. **(B,C)** Modeled predicted marginal effects for subjective and objective selection of sky, trees and water.

($p < 0.001$). The variance explained within the model was higher than that of the type of environment (marginal $R^2 = 0.049$ and conditional $R^2 = 0.533$)—however, the model's AIC = 53601.9 was relatively comparable to the previous model. Thus, we added to the model the effect of weather conditions (blue sky, cloudy or grey sky) with an alternative model: $EDB_{sky} \sim horizon + sky\ conditions + (1|participant) + (1|image)$. While the horizon effect remained statistically significant ($p < 0.001$), the grey sky condition was associated with the highest sky selection rate, the blue sky condition the lowest sky selection, and the cloudy sky was marginally significantly different from the grey sky ($p = 0.046$). The sky conditions contributed (marginal $R^2_{alt} = 0.064$) to the increased explanation of fixed effects of the entire model (conditional $R^2_{alt} = 0.532$). When compared, the AIC of the alternative model indicated general fit improvement with AIC = 53,588, and the likelihood ratio test suggested better overall performance [$X^2(2) = 18.39$, $p < 0.001$]. Furthermore, we have investigated the interactive effect between the horizon and sky conditions: $EDB_{sky} \sim horizon * sky\ condition + (1|sub) + (1|image)$. However, the model estimates indicated no significant interaction between the levels of horizon and conditions in the sky ($p > 0.05$) and the total variance explained by the interaction remained unchanged (marginal $R^2 = 0.065$ and conditional $R^2 = 0.532$). The model's AIC indicator was higher than that of the previous model (AIC = 53,593), and the likelihood ratio test revealed no significant difference between the models [$X^2(2) = 2.51$, $p = 0.643$]. Therefore, we assumed that modelling the additive effect of horizon and sky conditions better explained the sky selections.

In the next step, we wanted to account for different conditions determining the state of the environment. We added to the model the variable describing the year's season: $EDB_{sky} \sim horizon + sky\ conditions + season + (1|participant) + (1|image)$. The estimates predicted that autumn and winter in the image increased the likelihood of selecting sky as nature (see Figure 4A). The spring/summer was the only season statistically insignificant ($p > 0.05$). Moreover, the direct comparison of models indicated that despite an improvement in the AIC parameter ($AIC_{alt} = 53,587$), the difference between the models was statistically insignificant [$X^2(2) = 4.48$, $p = 0.106$], and the additive term did not substantially contribute to the explanation of fixed effects variance or overall model (marginal

$R^2 = 0.067$ and conditional $R^2 = 0.532$). However, due to the close association between sky conditions and season, we investigated the expected interaction between these two ($EDB_{sky} \sim horizon + sky\ conditions\ *\ season + (1|participant) + (1|image)$). The estimates showed a significant effect of all interactions. The results indicate that the autumn and grey sky condition predicted the highest rate of sky selection as nature. The grey sky also predicted the highest selections in spring/summer, but the blue sky elicited the highest number of selections in winter. Since the model showed improved performance ($AIC_{alt} = 53{,}566$), we tested the differences with the model of the effect of horizon and sky conditions. The interaction also seemed to explain a bigger part of the fixed effects in the model (marginal $R^2 = 0.087$ and conditional $R^2 = 0.531$). The likelihood ratio test showed a significantly better performance of the interaction model [$X^2(2) = 34.004$, $p < 0.001$]. Therefore, we consider this as the final model.

Sky affects judgment of naturalness

To test the hypothesis that perceiving sky as nature affects the subjective rating of naturalness, we fitted a GLMM model with naturalness ratings as the outcome. We sought first to explain the association between the subjective sky selection and rating as well as to compare its performance with the model of subjective tree selection. Then, we modelled the association between objective visibility of the sky, trees and the naturalness ratings. The aim of the analysis was to assess the similarity between subjective selection and the general effect of the objective label presence.

The baseline model treated sky selections as a fixed effect. We have used the same parameters for subjective tree selection scores (EDB trees). Our assumption was that the effect of sky selection as nature should be similar to or greater than the subjective selection of trees as nature. For this purpose, we limited the dataset to the images where both trees and sky were present (trees and sky >0, $n_{images} = 203$, $n = 5{,}071$). In this manner, we circumvented the problem of zero-inflation in EDB tree scores inside the model, caused by the absence of a particular label on the image. The analysis was performed stepwise, with the same model parameters as the previous models except for adding the Adaptive Gauss-Hermite Quadrature (AGQ) as the maximum log-likelihood term approximation. AGQ is commonly used in approximation of the intractable integrals with normal random effects. It is used as a viable alternative to Laplace approximation method (Jin and Andersson, 2020).

First, we fitted a GLMM for naturalness rating with fixed effect of EDBsky: $Naturalness \sim EDBsky + (1|participant) + (1|image)$. The model's diagnostics indicated mild underdispersion of residuals, but this did not seem to affect the model significantly. More sky selection as nature was found to be significantly positively associated with the rating of naturalness ($p < 0.05$) (Figure 4B). However, the overall contribution of the score to the explanation of the model's variance was minimal (marginal $R^2_{sky} = 0.001$ and conditional $R^2_{sky} = 0.422$). Next, we performed the same procedure with EDB trees as a fixed effect ($Naturalness \sim EDBtrees + (1|participant) + (1|image)$). Interestingly, the effect of trees on the rating of naturalness was found insignificant ($p = 0.273$) with EDB scores not contributing to the explanatory value of the variance in naturalness ratings (marginal $R^2_{trees} = 0.000$ and conditional $R^2_{trees} = 0.423$). As a formality, we have compared both models with a likelihood ratio test to confirm that sky scores model performs better than trees scores [$X^2(2) = 3.17$, $p < 0.001$]. In the last step we investigated if adding the tree selection to the model improved the model's explanatory value: $Naturalness \sim EDBsky + EDBtrees + (1|participant) + (1|image)$. However, adding tree selection did not significantly improve model performance (marginal $R^2_{trees} = 0.001$ and conditional $R^2_{trees} = 0.422$; $AIC_{alt} = 49376.6$; $X^2(1) = 0.49$, $p = 0.484$).

To investigate the effect of visibility, we fitted a model for naturalness ratings with experimental variables describing the state of the environment as fixed variables: percentage of sky on the image (instead of horizon, as a direct expression of visibility of the sky), sky conditions and season. The baseline model described the effect of sky visibility on the image on naturalness ratings: $Naturalness \sim percentage\ of\ sky + (1|sub) + (1|image)$. Generally, the model showed an association between the amount of sky displayed on the image and the rating of naturalness at the significant level ($AIC = 49365.9$). However, the sky visibility alone only minimally explained the variance within the ratings (marginal $R^2_{sky} = 0.011$ and conditional $R^2_{sky} = 0.422$). We have added weather conditions as an explanatory term: $Naturalness \sim percentage\ of\ sky + weather\ conditions + (1|sub) + (1|image)$. However, the effect of weather conditions was found statistically insignificant ($p > 0.05$, marginal $R^2_{sky} = 0.013$ and conditional $R^2_{sky} = 0.422$) across the weather conditions and the model overall did not perform significantly better [$X^2(2) = 1.06$, $p = 0.588$] than baseline. For that reason, we did not retain the weather conditions within the model and proceeded to extend it by the season condition: $Naturalness \sim percentage\ of\ sky + season + (1|sub) + (1|image)$. Here, the model's estimates showed a significant effect of winter and spring/summer conditions. Winter and lower sky visibility were found to be associated with increased naturalness ratings. On the other hand, the spring/summer season and low sky visibility were responsible for significantly lower scores. The season was found to moderately contribute to the explanation of fixed effects variance (marginal $R^2_{sky} = 0.033$ and conditional $R^2_{sky} = 0.423$) and was responsible for significant improvement in the performance over the baseline model [$X^2(2) = 11.77$, $p < 0.05$]. In the case of the presence of trees on the image, the GLMM was fit for naturalness ratings with the percentage of trees on the image as a fixed effect: $Naturalness \sim percentage\ of\ trees + (1|sub) + (1|image)$. As predicted, the baseline model estimates indicated that the visibility of trees on the image played a significant ($p < 0.001$) role in the rating of naturalness. The variance explained by this effect within the model (marginal $R^2_{trees} = 0.117$ and conditional $R^2_{trees} = 0.419$) was relatively higher than that of the visibility of the sky and so was the performance of the model [$X^2(2) = 70.12$, $p < 0.001$]. That

alone indicates that the presence of the trees impacted the naturalness ratings more than the presence of the sky. In the Supplementary material: Extended modelling, we have also extended the model for weather and seasonal conditions. Altogether, the model of tree selection indicated that the pattern of effect prediction is better than that of the sky model (Figure 4C).

The blue and the other blue: Sky and water

To investigate if the two blue spaces: sky and water were associated with the perception of nature to the same degree we have fitted a GLMM model for naturalness ratings with subjective water selection as a fixed variable. For this purpose, we likewise limited the sample size to the images where both water and sky were present (water and sky >0, $n_{images} = 73$, $n = 931$). Due to significant limitation of the dataset we chose to rerun the subjective sky selection model (*Naturalness* ~ *EDBsky* + *(1|participant)* + *(1|image)*). Consistently, the model predicted significant effect of sky on naturalness ($p < 0.05$), but explained a slightly higher amount of variance (marginal $R^2_{sky} = 0.004$ and conditional $R^2_{sky} = 0.428$). The model of subjective water selections (*Naturalness* ~ *EDBwater* + *(1|participant)* + *(1|image)*) indicated that the water selections were not significantly ($p = 0.823$) associated with ratings of naturalness (Figure 4B, marginal $R^2_{water} = 0.000$ and conditional $R^2_{water} = 0.430$). Consequently, the direct comparison with likelihood ratio test, confirmed that the subjective sky selections predicted the naturalness ratings better than the selections of water [$X^2(0) = 0$, $p < 0.001$]. Finally, we have tested if the model with association between naturalness (*Naturalness* ~ *Water* + *(1|participant)* + *(1|image)*) and objective visibility of the water ($p < 0.001$, marginal $R^2_{water} = 0.032$ and conditional $R^2_{water} = 0.372$, $AIC_{water} = 9{,}200$) was significantly better than that of the objective visibility of the sky ($p = 0.270$, marginal $R^2_{water} = 0.001$ and conditional $R^2_{water} = 0.433$, $AIC_{sky} = 9{,}215$). The likelihood ratio test showed a significant difference [$X^2(0) = 14.86$, $p < 0.001$] indicating that the objective water visibility model has better association than that of the objective visibility of the sky.

Discussion

The main aim of our study was to attempt to close the gap in empirical evidence on the significance of the sky to human perception of nature. We sought to embed the sky as an integral part of the scene, invariant to environment type. In general, participants' selection of sky was not prioritized when selecting elements of nature, but was represented significantly among selections. Instead, participants focused on elements of greenery present in the landscape, i.e., trees, vegetation. Nevertheless, the sky was clearly selected as nature when available in the image. The subjective selection of sky and the trees were associated to an equal degree with the total number of selections made on the images. The correlations between a subjective rating of naturalness and objective visibility of sky was weaker (but significant) than the correlation with objective visibility of greenery.

More detailed analyses revealed additional interesting findings. The experimental condition of environment type (nature, some nature, some urban, and urban) had no effect on the selection of sky as nature. Although the perception of the sky as nature was independent of the environment in which the choice was made, it depended on the level of horizon (low, medium, and high) on the picture. Interestingly, the less sky was visible in the pictures, the more participants chose sky as an instance of nature. The weather condition on the sky visible on the image seemed to matter, with people being more likely to select the sky as nature when the sky was grey rather than blue or cloudy. This finding is interesting since so far the effect of weather was found to affect the preference for the scene in sunny and bright sky conditions. The effects of these two factors (amount of sky and weather) seem to be independent of each other. However, the weather conditions interacted significantly with the season of the year. We can conclude that in our investigation of whether people consider sky as nature, there is compelling evidence that the perception of sky as nature depended on multiple conditions. The evidence suggests that despite not being strong, the sky was positively associated with the subjective selections of nature and can be considered as an integral part of it. Multiple relationships appeared to explain that the conditions of the environment matter more in considering sky as nature than the type of environment in which sky is presented. The association of subjective sky selection with the visible small amount of the grey sky is particularly intriguing. It is possible that high horizon levels attract participants' attention for the purpose of orienting participant within the space (Rogers, 1996; Patterson et al., 1997) and therefore unintentionally guiding attention toward the presence of sky (Ooi et al., 2001). Yet, it is difficult to find an explanation for the amplification of the effect in grey sky conditions and the winter season.

Our second hypothesis stated that sky affects the subjective perception of naturalness. In the case of predictability of naturalness ratings by subjective sky selection, the results revealed that sky selection as nature was positively associated with naturalness ratings, unlike the selection of trees and water. This result is in line with earlier evidence, including by Beute and de Kort (2013) who concluded that there is an explicit preference for natural environments with sunny and bright conditions. Moreover, the explanatory value of the sky model did not benefit from the summary effect of subjective selection of the sky and the trees. Interestingly, we found that when we used the objective presence of sky and tree visibility to predict naturalness ratings and objective visibility of the sky remained significant but weak. In contrast, the association between objective visibility of the trees was significantly stronger. Additionally, the association was further modified by weather condition and seasonal changes. Higher naturalness ratings were associated with the objective presence of the sky in winter. Importantly, the presence of the trees affected naturalness ratings more than the presence of the sky. One possible explanation for this could be a subliminal effect of tree presence which is stronger than that of the sky. The

presence of trees and vegetation on images has in the previous literature frequently been associated with a high level of non-straight edge density and fractal dimension (Berman et al., 2014; Patuano, 2018; Schertz and Berman, 2019). There is evidence that these spatial properties are associated with the perception of naturalness and that it affects bottom-up visual processing (Kardan et al., 2015).

Lastly, we have compared the naturalness association with a subjective selection of sky and water. The result showed no significant association with subjective water selection but we found subjective sky selection congruent with previous results. However, we observed an association between objective presence of water and ratings of naturalness. To summarize, the subjective sky selection seemed to explain the naturalness ratings better than subjective selection of water, but on the other hand the objective presence of water explained naturalness ratings better than objective presence of the sky. White et al. (2021) explained variances in different associations between blue and greenspaces as a result of overall exposure and accessibility to the space. There is also the possibility that the above-mentioned effect of low-level spatial properties of the water surface may make them less likely to be selected as nature. In the end, we can conclude that the positive association of sky with subjective ratings of naturalness, although weak, extends through subjective and objective measures. Sky results were found to be more consistently linked with naturalness than trees or water. Such results may corroborate the earlier indirect evidence where higher tree cover density, which resulted in more occlusion of the sky, slowed recovery from stress in men (Jiang et al., 2014). Similarly, Gatersleben and Andrews (2013) found that within the natural environment openness of the space, and therefore direct access to sky, was more beneficial to restoration than tree canopy coverage. In their paper, Masoudinejad and Hartig (2018) framed that the restorative quality of the sky can be theoretically framed in ART. They concluded that fascination focused the attentional resources and was influenced by the amount of visible sky. Our evidence suggests that a higher horizon level may guide these resources toward the sky, increasing the frequency with which sky was selected as nature, despite greater visual view to vegetation. Conclusively, we see that sky was considered as nature and played a role in the perception of the environment. However, this role needs further rigorous investigation.

To our knowledge, this is the first study specifically focusing on the place of the sky in the perception and effect of the natural environment. The study benefits from a robust experimental design that aimed to assess the association between sky and the diversity of the environments. We have operationalized the hypotheses by the use of conscious explicit selection of nature as a method of probing the hypothesized connection. There is still a potential in implicit investigation of this relationship by obtaining eye-tracking data to infer attentional processes. Such methods are already in use to investigate the cognitive effects of natural versus urban environments (Stevenson et al., 2019). That way we could directly ascertain if the subjective selection patterns correspond with the implicit effects of the sky.

The study is not without limitations. The experiment was conducted online, during the global pandemic and under lockdown conditions. This might have had some residual effect on the participant's attitude toward nature. During data analysis, the biggest challenge was a problematic distribution of acquired measurements that required us to employ complex statistical modelling. GLMMs are known for their problematic relationship between model complexity and model performance (Breslow and Clayton, 1993). Moreover, the nature of the dataset also created an issue with overdispersion, underdispersion, and overall problems with the distribution of residuals. It has to be noted that the individual effect of participant and image explains a significant amount of variance across all of the models.

Our main conclusions open new prospects for providing better explanations for the role of environment in mental health and wellbeing. We hope that the encouraging results will motivate further interest in studying the importance of sky in environmental psychology research. Specifically, the possible lines of investigation include the effect of the access to sky, importance in visual selection and a detailed investigation of the sky's role in urban environments. Ultimately, such knowledge may have the potential to impact urban-design strategies and policymaking.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. The materials and methods used to conduct the experiment are available in following repositories: OSF: https://osf.io/w9rcq/ GitHub: https://github.com/PuddleJumper2018/nature_gradient/.

Ethics statement

The studies involving human participants were reviewed and approved by Local Psychological Ethics Committee at the Center for Psychosocial Medicine (LPEK-0280) at University Medical Center Hamburg-Eppendorf. The patients/participants provided their written informed consent to participate in this study.

Author contributions

IMS designed and coordinated the study, experimental design, stimuli selection and preprocessing, performed the main data analysis and modelling, prepared figures and wrote the manuscript. AÖ coordinated the study, collected the data, and performed paradigm validation. SS designed and coordinated study, experimental design and stimuli selection, and reviewed the manuscript. SK had the idea for the study, reviewed the design, supervised data acquisition and analysis, and reviewed the

manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.932507/full#supplementary-material

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The contour effect: Differences in the aesthetic preference and stress response to photo-realistic living environments

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The interest in the response to contours has recently re-emerged, with various studies suggesting a universal preference for curved over angular stimuli. Although no consensus has yet been reached on the reasons for this preference, similar effects have been proposed in interior environments. However, the scarcely available research primarily depends on schematic or unmatched stimuli and faces heterogeneity in the reported results. In a within-subject design, we investigated the claimed contour effect in photo-realistic indoor environments using stimulus material previously tested in virtual reality (VR). A total of 198 online participants rated 20 living room images, exclusively manipulated on the contours (angular vs. curved) and style (modern vs. classic) levels. The scales represented aesthetic (beauty and liking) and stress (rest and stress) responses. Beyond our main focus on contours, we additionally examined style and sex effects to account for potential interactions. Results revealed a significant main effect of contours on both aesthetic (η^2_g=1–2%) and stress (η^2_g=8–12%) ratings. As expected, images of curved (vs. angular) contours scored higher on beauty, liking, and rest scales, and lower on stress. Regarding interactions with style, curvature was aesthetically preferred over angularity only within images depicting modern interiors, however, its positive effect on stress responses remained significant irrespective of style. Furthermore, we observed sex differences in aesthetic but not in stress evaluations, with curvature preference only found in participants who indicated female as their sex. In sum, our study primarily confirms positive effects of curvature, however, with multiple layers. First, the impact on aesthetic preference seems to be influenced by individual and contextual factors. Second, in terms of stress responses, which might be especially relevant for designs intended to promote mental-health, the consistent effects suggest a more generalizable, potentially biophilic characteristic of curves. To the best of our knowledge, this is the first study to demonstrate these effects in fully-matched, photo-realistic, and multi-perspective interior design stimuli. From the background of a previous VR trial from our research group, whereby the same rooms did not elicit any differences, our findings propose that static vs. immersive presentations might yield different results in the response to contours.

KEYWORDS

interior design, contours, style, aesthetic preference, stress response, sex-related differences, biophilia

Introduction

The human-environment interaction has recently been in the focus of many fields of research from humanities to natural sciences, with bourgeoning interdisciplinary efforts attempting to link characteristics of sensory stimuli to psychological responses and mental states. It is now widely accepted that the aesthetics of our physical surroundings, whether natural or man-made, can play a meaningful role in shaping our mood and overall well-being (Wohlwill, 1976; Gibson, 1979; Evans and McCoy, 1998; Gifford, 2002; Evans, 2003; Staats et al., 2003; Elliot and Maier, 2014; Coburn et al., 2020). Yet, little is known about this relationship within built settings, particularly with regards to the identification of features that drive the observed effects and the underlying psychological mechanisms (Eberhard, 2009; Graham et al., 2015; Coburn et al., 2017; Bower et al., 2019).

Affect: Aesthetic preference vs. stress response

During an aesthetic experience, visual properties and higher-order content are segregated along multiple brain regions involved in the regulation of reward and judgment (Chatterjee and Vartanian, 2014). An active simultaneous involvement of emotional, cognitive, and contextual factors is suggested to mediate such aesthetic encounters (Chatterjee and Vartanian, 2014; Coburn et al., 2017). Among the various proposed theoretical models addressing the alternating roles of affect and cognition, it has been commonly agreed that evaluations/judgments are the result of bottom-up stimulus properties and top-down appraisals (Leder et al., 2004; Mastandrea and Bartoli, 2011; Chatterjee and Vartanian, 2016; Chamberlain, 2022). Experiencing a positive and pleasant aesthetic encounter will therefore increase positive affect (Leder et al., 2004), potentially benefiting health and well-being (Coburn et al., 2017). Despite the remaining open questions of which subjective (top-down) and objective (bottom-up) features exactly drive (interindividual) differences in empirical aesthetics, consistent response patterns were found and attributed to certain aesthetic primitives. Stimulus properties such as contour shape (Bar and Neta, 2007; Vartanian et al., 2013), color (Palmer et al., 2013; Strauss et al., 2013; Elliot and Maier, 2014), as well as symmetry (Tyler, 2003; Bertamini et al., 2018, 2019), order, complexity (Nadal et al., 2010; Van Geert and Wagemans, 2021), and global image properties (e.g., fractality) were proposed as objective predictors of aesthetic preference (Chamberlain, 2022). However, other approaches stress the idiosyncrasies of preferences, demonstrating a stronger shared taste for natural or naturally inspired aesthetic domains as opposed to artifacts of human culture (Vessel et al., 2018).

Although aesthetic preference has been long argued as part of the affective domain (within the broad pleasantness dimension), a differentiation between conscious responses (i.e., preference as cognitive accompaniments of an emotion) and innate ones (i.e., affects) has been made (Ulrich, 1983). Beyond preference, physical environments can affect the stress response inducing changes on the psychological, physiological (bodily), hormonal (cortisol), and behavioral levels (Ulrich et al., 2008). For instance, it has become increasingly clear that the exposure to natural environments can reduce psychological and physiological stress (Ulrich et al., 1991; Berto, 2014), with new evidence of a causal effect on stress-related brain regions (Sudimac et al., 2022). Such mechanisms are linked to the biophilia hypothesis which suggests an innate evolutionary-based tendency for humans to connect with nature (Wilson, 1984). This hypothesis has been extended onto man-made environments, and frameworks of biophilic design have emerged (Browning et al., 2014; Kellert and Calabrese, 2015; Salingaros, 2015, 2019; Coburn et al., 2019), proposing that elements such as light, colors, fractals, representation of nature, and also curves, not only increase perceived aesthetic value, but can also reduce stress in humans (Salingaros, 2019; Yin et al., 2020).

The contour effect, learnt or innate?

Among the many environmental features, contour shapes have been proposed to play a fundamental role in how we perceive our surroundings (Loffler, 2008; Chuquichambi et al., 2022). Over the last two decades, the investigation of contours has recently regained momentum with seemingly robust evidence supporting a universal positive effect of curvature (Bar and Neta, 2007; Gómez-Puerto et al., 2016; Palumbo and Bertamini, 2016; Cotter et al., 2017). When presented with images showing lines, abstract/geometric shapes, drawings/images of real objects, or sketches/images of products (e.g., packages, car interiors), it appears that people prefer curved over angular or edgy stimuli (Gordon, 1909; Leder and Carbon, 2005; Bar and Neta, 2006; Silvia and Barona, 2009; Westerman et al., 2012; Palumbo et al., 2015; Chuquichambi et al., 2021). Findings were replicated under different experimental paradigms, further exploring other possible stimulus-related mediators, but also interindividual differences (moderators) of this phenomenal effect (refer to Tawil et al., 2021 and Corradi and Munar, 2019 for a more detailed review).

However, the origin of this phenomenon is still under debate, with no consensus reached as to the psychological mechanisms that drive it. On the one hand, the cumulative evidence from humans of different ages (including newborns and infants) (Fantz and Miranda, 1975; Jadva et al., 2010) and cultures (Gómez-Puerto et al., 2018), as well as non-human animals (Munar et al., 2015), facilitated a conceivable notion of an evolutionary adaptive behavior, possibly developed through the avoidance of the potentially harmful edges (Bar and Neta, 2006). This "threat hypothesis" was backed up by neuroimaging data showing the activation of cerebral areas involved in processing of threat and fear (i.e., amygdala) when viewing greyscale images of edgy

everyday objects, as opposed to their curved counterparts (Bar and Neta, 2007). Besides the evolutionary-based approach, other research found that the preference for curvature can also be modulated by trends or Zeitgeist effects (Carbon, 2010). Zeitgeist effects -translated literally as "spirit of the times"– designate time-related fluctuations in values (for instance, aesthetic ones) influenced by societal phenomena. This perspective noted the omnipresence of curvature in current contemporary times, enabled by technological advancements that allow the production of curves in time and cost-efficient ways, highlighting a confounding factor of time-specific preferences. Conversely, a different approach considered that the preference might stem from the shape of the curvature by itself, which provides good stimulus continuity (Wagemans et al., 2012), and thereby answers to one of the main Gestalt principles (Bertamini et al., 2016). A review developed a unifying framework for research on the psychological and neural mechanisms of curvature preference, distinguishing between sensorimotor-based explanations and those originating from appraisals (Gómez-Puerto et al., 2016). The review proposed that the learnt versus evolved/innate origins of the preference are not mutually exclusive, however, they require further research to uncover cultural and evolutionary foundations.

Contours in interior environments

Extending on the empirical evidence for this suggested contour effect, an encouraging body of experimental literature proposed similar patterns in the context of architecture and interior design. A positive response to curved/curvilinear as opposed to angular/rectilinear spaces was observed when reacting to images representing matched sketches/line drawings (Madani Nejad, 2007), colored (van Oel and van den Berkhof, 2013) or greyscale (Dazkir and Read, 2012) computer-generated scenes, and images of real environments (Vartanian et al., 2013, 2019), in addition to drawings of building facades (Ruta et al., 2019). Studies have shown that curvature was preferred over angularity and resulted in higher self-reported positive emotions such as pleasure (Küller, 1980; Hesselgren, 1987; Dazkir and Read, 2012; van Oel and van den Berkhof, 2013), relaxation, safety, privacy (Madani Nejad, 2007), in addition to a self-reported decision to approach (Dazkir and Read, 2012).

Most of previous studies used subjective semantic scales to depict affective and behavioral responses (e.g., valence, arousal, and approach-avoidance), with recent approaches including neuroscientific measures such as neuroimaging (Vartanian et al., 2013; Banaei et al., 2017). Although earlier research has attempted to cover a wider range of emotional responses, more recent studies have been focused on aesthetic preference measures, such as liking, pleasantness, attractiveness, and beauty. We note however that the main portion of the evidence on the contour effect originates from empirical aesthetics, a discipline highly concerned with the question of hedonic tones. This has been noted as a general limitation of the emerging lines of research investigating the effects of architectural spaces, which are mostly restricted to aesthetics and disregard other components of the cognitive-emotional dimension of architecture (Higuera-Trujillo et al., 2021). Beyond aesthetic preference and hedonic tones, environmental psychologists explore affective responses from additional domains, and highlight a particular role of the environment in regulating emotions and affecting mood (e.g., stress reduction Ulrich et al., 1991), thereby influencing human psychology and physiology.

In terms of stimulus material, previous research mainly adopted traditional presentation methods and used either matched but unrealistic stimuli with a limited number of images [e.g., $N=8$ in Madani Nejad (2007); $N=4$ in Dazkir and Read (2012)], or a higher number of images of real environments at the (substantial) cost of accepting a considerable number of confounding factors (Vartanian et al., 2013, 2019), adding in both cases further limitations to the generalizability of results. Research investigating objects, on the other hand, ensured matched stimuli, and presented greyscale photographs of real objects (Bar and Neta, 2007; Cotter et al., 2017) or line drawings (Chuquichambi et al., 2021; Sinico et al., 2021). However, to the best of our knowledge, all previous studies were typically restricted to one image per environment/object, thereby showing stimuli exclusively from one side. It is worth noting that the subject has received little experimental scrutiny beyond traditional stimulus presentation methods (i.e., static images), with very limited endeavors adopting real life objects/environments or virtual reality (VR) to reflect the three-dimensional experience. When comparing with traditional presentation modes, evidence on the curvature effect in virtual environments seems inconsistent. Empty virtual rooms with curved boundaries were found to elicit more pleasantness and arousal than those with linear boundaries (Banaei et al., 2017), while no effects were observed in another study where participants were immersed in photo-realistic virtual interiors (Tawil et al., 2021).

Additional (heterogeneous) evidence is emerging with extended research efforts and attempts to uncover the underlying psychological and neuronal mechanisms of this positive effect of curvature in interior contexts. While neuroimaging data resulting from an investigation of everyday objects demonstrated an activation of the amygdala when individuals perceive edgy stimuli (Bar and Neta, 2007), this was not observed with interior design stimuli (Vartanian et al., 2013), Conversely, curvilinear environments activated the medial orbitofrontal cortex. Subsets of the same image set were used in following studies yielding inconsistent effects, with the latest one finding a preference for rectilinear over curvilinear interiors (Palumbo et al., 2020). Interestingly, in the same study, curved abstract shapes were still preferred over angular ones. Of note, unlike the majority of previous research, in this study participants were mostly men.

Indeed, recent evidence suggested that the positive curvature effects might be moderated by individual factors such as gender and academic degree, highlighting that most of the findings from

previous studies relied largely on female psychology students (Palumbo et al., 2021). Earlier research, however, has identified sex differences, linking contour preference and sketch production to symbolic representations of the human body morphology (Munroe et al., 1976). Similar tendencies were also observed in a previous study from our lab, where a significant positive effect of angular rooms (on cognitive performance and subjective ratings of affect and spatial experience) was found in male when compared to female participants (Tawil et al., 2021). However, to date, no study has yet attempted to examine these differences in contours evaluation with interior design stimuli.

The present study

Within the scope of the present study, we aimed to investigate the response to contours in interior environments, while addressing some of the limitations of previous research. Given that our earlier investigation of these effects in VR returned null results, we opted to test our stimulus material under the traditional presentation paradigm (i.e., presenting 2D static images), similarly to the biggest portion of previous studies. However, we provided more than one perspective of the same environment. Eventually, we presented 20 well-matched photo-realistic images representing a contrast in contours (angular vs. curved). We included style (modern vs. classic) as a second-level factor to take into consideration the evidence on a Zeitgeist effect potentially moderating curvature preference (Carbon, 2010). For the purpose of exploring internal processes possibly responsible for the assumed positive effects of curved contours beyond mere preference, we distinguished between aesthetic and stress responses. Aesthetic preference was represented by self-reports on beauty and liking, two measures that were mostly used in previous research. Stress response, on the other hand, was explored through the lens of the basic physiological antagonism parasympathetic – sympathetic activation, therefore, we included subjective evaluations of rest and stress. Moreover, we took the decision (after pre-registering) to control for a balanced sample in terms of reported biological sex in order to identify any potential differences. We expected a positive impact of curved contours on the explicit responses collected *via* subjective ratings of aesthetic preference (i.e., higher beauty and liking scores) and stress response (i.e., lower stress and higher rest scores). Conversely, considering the scarcity of evidence in the literature, we did not have a strong *a priori* prediction regarding any of the interactions of contour with style and/or biological sex.

Materials and methods

Participants

Based on unpublished results from a previous study piloting an implicit task using similar stimuli as in the present study (i.e., static images), a sample size estimation using G*Power—version 3.1 (Dusseldorf University, Dusseldorf, Germany) resulted in the need for 138 participants to enable a small effect size ($f = 0.10$) with an alpha of 0.05 and a power of 0.80 for a within-subjects repeated measures ANOVA. Due to the potentiality of technical errors (or abortion mid-experiment), we aimed for a sample of up to 200 participants, to obtain at least 150 full datasets. The additional sample buffer was considered because the *apriori* effect size was based on one experimental task only. Recruitment was carried out *via* the online platform Prolific (www.prolific.co), and was stratified by sex (50:50). Eventually, 198 healthy adults were included in the study (aged between 18 and 69 years, $Mdn = 27.0 \pm 10.9$; 50% female participants), with no severe/uncorrected visual impairments. Further in−/exclusion criteria included fluency in German and self-reported absence of diagnosed mental or neurological disorder. Subjects were compensated with 8£ for participating in all parts of the experiment, which lasted for approximately 1 h in total. For further sample characteristics, see Table 1.

Stimulus material

The stimulus material was derived from a previous study where stimuli were presented in VR (Tawil et al., 2021). Minor adjustments were implemented to achieve further control over possible confounding variables. Two pairs of virtual living rooms were created using Autodesk's 3ds Max ($L \times W \times H = 4.9 \times 3.9 \times 3$ meters) and implemented in the gaming software Unity (version 2019.2.1f1, 64-bit). Rooms of each pair were identical in their design, except that one had angular objects, while the other had curved counterparts (factor 1 contour: angular vs. curved). The second contrast was the interior design style (factor 2 style: modern vs. classic). Each room included 18 objects that were matched in terms of bounding sizes, materials, and colors, and contrasted according to the study design factors (a comparative list of all objects from all rooms along with their images and dimensions is included in section 1.3 of the Supplementary material). The pairs were designed (by an expert in architecture) with the main objective of providing balanced and proportional objects that still reflect the same design spirit/style, without appearing unrealistic or unfamiliar. Therefore, they were inspired by common furniture that exist in both contour versions. In terms of style, we intended a periodic contrast rather than one relating to specific aesthetics, in order to investigate the previously proposed Zeitgeist effect (Carbon, 2010). However, to discriminate between the styles, the "classic" pair had items that originate from more traditional design periods (e.g., "Rococo" Louis XV furniture, "neoclassical" Louis XVI furniture, and "Georgian" sliding slash windows), while the "modern" one included items inspired by "minimalism," a much more recent style characterized by simplicity and clean lines. To provide diversity in the stimulus set, different cameras were placed inside the virtual rooms to capture different viewpoints from a first-person perspective. Images were rendered using Unity High Definition Render Pipeline (HDRP, version 6.9.1), and captured within Unity using

TABLE 1 Sample characteristics (N=198).

	Range[a]	*M*	*SD*	Freq.	%
Biol. variables					
Median age	18–69	27.0	10.9	–	–
Self-reported biological Sex (male/ female)[b]		–	–	99/99	50/50
Net income					
<1.250	–	–	–	84	42.4
1.250–1749	–	–	–	30	15.2
1.750–2.249	–	–	–	16	8.1
2.250–2.999	–	–	–	28	14.1
3.000–3.999	–	–	–	13	6.6
4.000–4.999	–	–	–	6	3.0
>5.000	–	–	–	8	4.0
do not want to answer	–	–	–	13	6.6
Education					
Median years of education[c]	5–13	12	1.33	–	–
Nominal level of education[d]					
No school degree	–	–	–	1	0.5
Low school degree	–	–	–	2	1.0
Middle school or lower	–	–	–	18	9.1
Highschool (A-levels)	–	–	–	177	89.4
Architectural/aesthetics knowledge					
Profession architecture/ interior design – yes	–	–	–	5	2.5
Median VAIAK – interest[e]	11–74	37.0	14.5	–	–
Median interior design interest VAS[f]	0–100	61.0	27.5	–	–
Median interior design – knowledge VAS[f]	0–100	23.0	23.8	–	–
Psychopathology					
Median DASS21- stress[g]	0–36	10.0	7.24	24	12.1
Median DASS21 – anxiety[g]	0–28	2.0	5.32	41	20.7
Median DASS21 – depression[g]	0–42	4.0	7.95	50	25.3

[a]Observed value range.
[b]The terms "male" and "female" are used as grouping adjectives, as this was how participants were asked to (dichotomously) classify themselves.
[c]School and professional education.
[d]Based on German education system.
[e]VAIAK, Vienna Art Interest and Knowledge Questionnaire, interest subscale, total scores can range from 1 to 77, in the original validation study, the mean for lay people was M = 37.9, SD = 12.9 (Specker et al., 2020).
[f]Visual analogue scale (0–100) to rate interest or knowledge concerning architecture and interior design.
[g]Values under frequency column are the number of subjects reaching a clinically meaningful cut-off (i.e., moderate severity) on the DASS21, depression, Anxiety and Stress Scale 21. The terms "male" and "female" are used as grouping adjectives, as this was how participants were asked to (dichotomously) classify themselves.

the tool "Screenshot Utility",[1] downloaded *via* the Unity Asset Store. Image size was set to 5,075 × 2,160 pixels, 4 K resolution with ratio 21:9. Since we aimed to control for low-level image features [using ImageDecomposer[2] provided by Berman and colleagues (Berman et al., 2014; Kardan et al., 2015)], eventually, five out of the 15 generated images were selected per room, capturing all angles (for details on the low-level feature values and t-tests to compare curved vs. angular and modern vs. classic stimuli, please refer to section 1.1 of the Supplementary material) and a total of 20 images were included in the final stimulus set (the virtual cameras' positions are shown in Figure 1 for each of the perspective views). Each image belonged to one of the four categories: angular modern (AM), curved modern (CM), angular classic (AC), and curved classic (CC). Examples of the stimuli used are shown in Figure 1 (refer to section 1.2 of the Supplementary material for the complete stimulus set).

Experimental design and procedure

The experiment was implemented online using Inquisit 6 (millisecond, 2021), and a link to the study was provided for the participants on the online-recruitment-platform Prolific,[3] with a

1 https://assetstore.unity.com/packages/tools/utilities/screenshot-utility-177723

2 https://www.dropbox.com/sh/wykarfxm4jnhda0/AAAx8p3tIFBEqTdLSNIlnGOla?dl=0

3 www.prolific.co

FIGURE 1
Stimulus material. Left: Plan of the room illustrating the five viewpoints/perspectives, numbered according to the order of presentation (angular modern condition is displayed as a room example). All cameras were positioned to simulate eye view from standing position (approximately 1,500 mm), except for camera 1 (marked with a star (*)) which was placed to replicate a view from a sitting position. Right: Example stimuli representing the 2×2 design and depicting "perspective 5" in all four conditions: angular modern (AM), curved modern (CM), angular classic (AC), and curved classic (CC).

completion code shown at the end for collection of the monetary compensation. Subjects were first presented with the study information, asked for their informed consent, and answered questions concerning the eligibility criteria. The experiment included three main sections. First, participants responded to a set of four different reaction time paradigms (1) *approach-avoidance task* (AAT; Wiers et al., 2011), (2) *implicit association task* (IAT; Greenwald et al., 1998), (3) *dot-probe* (DP; Bradley et al., 1992), and (4) *manikin task* (MT), (De Houwer et al., 2001)] that were intended to capture implicit responses, but which are not part of the current paper. Second, participants filled out questionnaires (only those reported in demographics later on in this paper are fully cited here) assessing socio-demographic details, general interest/knowledge in arts and architecture (adapted from The Vienna Art Interest and Art Knowledge Questionnaire, VAIAK; Specker et al., 2020), preferred interior design styles, tendencies to depression, anxiety, and stress to check psychopathology levels (DASS-21; Lovibond and Lovibond, 1995), and personality traits, in addition to information about growing up, current housing conditions and exposure to nature. Within the socio-demographic questionnaire, participants were also asked to indicate their biological sex (male or female), thus, for reasons of simplicity, we will be using the term "sex" when referring to related potential differences, and the adjectives "male" and "female" for the subgroups of participants who indicated either category. In the third part, which constitutes the main focus of the present analysis, participants responded to two sets of rating tasks, created for the purpose of this experiment. Each set was composed of four blocks, randomized across participants. Responses were collected on visual analogue scales (VAS, 0–100, numbers were invisible to participants to avoid direct comparisons) anchored with statements on both endpoints and shown below the to-be-rated image (for details on the questions in German language, see Supplementary Table 1). Images were set to 50, 50% (height, width) of their original size and placed at the center of X (50%) and slightly upwards (30%), relative to the screen size of participants (example slides are shown in Figure 2 below).

Rating task 1 – General appraisal scale (GAS)

In each of the GAS blocks, participants rated the four images displayed in Figure 1 (AM, CM, AC, CC; depicting a general perspective view from the door) on six dimensions representing a general spatial evaluation (VAS scales 0–100). Thus, a total of 4 (images) × 6 (rating dimensions) = 24 ratings were completed by each participant. The order of the rating dimensions was kept identical across blocks (i.e., edginess, roundness, curiosity, novelty, order/structure, and complexity), but images were presented in random order (refer to Figure 2 below). We will only report ratings on edginess and roundness, as these scales were intended as a stimulus manipulation check. The items (translated from German) were for *edginess* "How edgy do you perceive this room to be?" (left anchor: [0] "not edgy at all," right anchor: [100] "very edgy"), and for *roundness* "How round do you perceive this room to be?" (left anchor: [0] "not round at all," right anchor: [100] "very round").

Rating task 2 – Aesthetic and stress response (ASR)

Rating scales of the ASR represented "aesthetic preference", namely, *beauty* and *liking,* that were mostly used in previous studies on contours [e.g., (Vartanian et al., 2013; Palumbo et al., 2020)], in addition to "stress responses", operationalized to resemble basic psycho-physiological states in the form of self-reports on *rest* and *stress* (adapted from Madani Nejad, 2007). Blocks of the ASR scale were each related to one different dimension (beauty, liking, stress, rest), and presented in randomized order. Within every randomized block, participants rated each of the 20 stimuli, always presented in the same order, hence a total of 80 responses were collected from each participant (20 trials × 4 blocks) (refer to Figure 2). The items (translated from

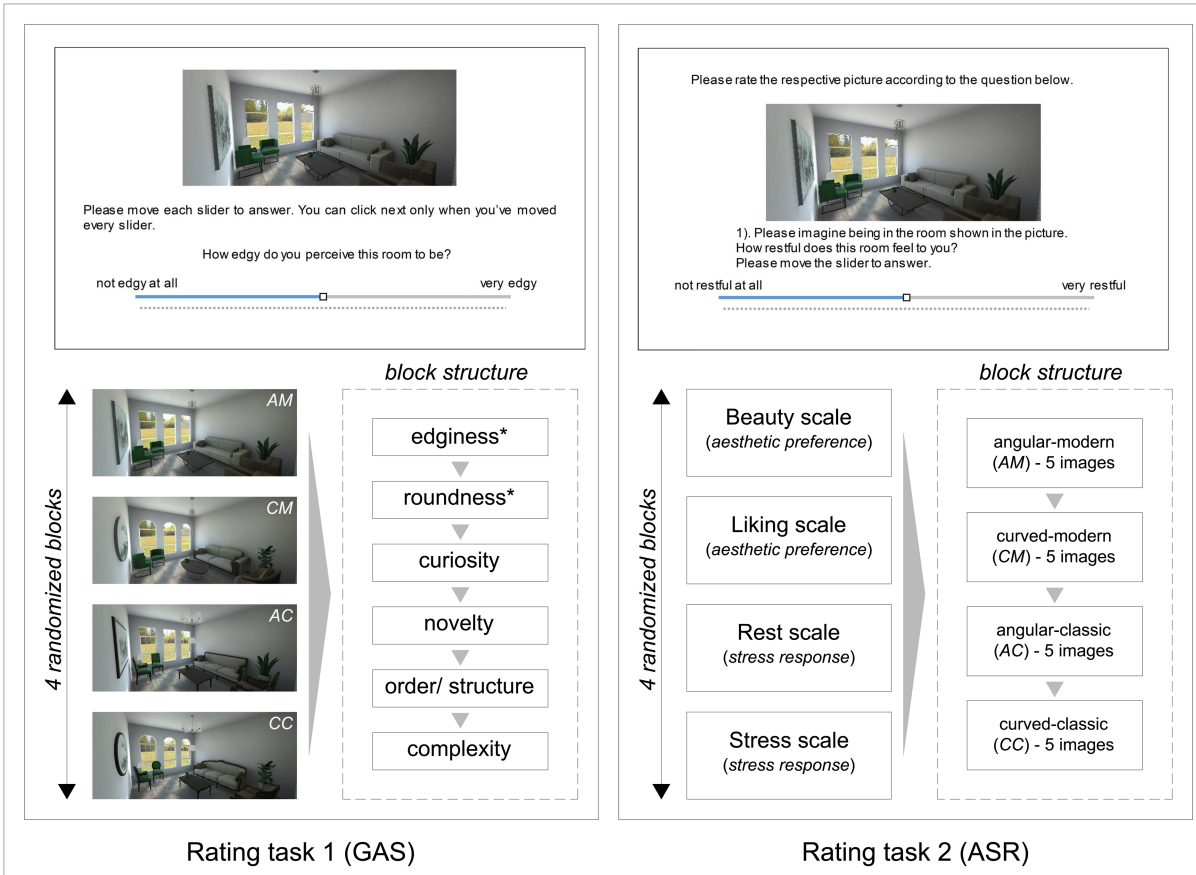

FIGURE 2
Illustration of the rating tasks structure. Left: Rating task 1 – General appraisal scale (GAS), consisting of four randomized blocks, each including six ratings (DV) of the same image (IV). Dimensions marked with a star (*) were meant for manipulation check and were reported within the present analyses. An example slide is illustrated on top of the structure, depicting "edginess" rating. Right: Rating task 2 – Aesthetic and stress response (ASR), consisting of four randomized blocks, each including ratings for 20 images (IV) on one single dimension (DV). The example slide shows "rest" rating scale. Both example trials are reconstructed and translated from German for illustration purposes.

German) were for *liking* "How much do you like the room shown in this picture" (left anchor [0] "not at all," right anchor [100] "very much"), for *beauty* "Please rate the beauty of the room shown in this picture" (left anchor [0] "not beautiful at all," [100] "very beautiful"), *rest* "Please imagine being in the room shown in the picture. How restful does this room feel to you?" (left anchor [0] "not restful at all"; right anchor [100] "very restful"), and for *stress* "Please imagine being in the room shown in the picture. How would you describe your emotional reaction?" (left anchor [0] "relaxed"; right anchor [100] "stressed").

Data analysis

We preregistered our research plan (which can be retrieved from https://aspredicted.org/B65_HP6) before the start of the study, as part of a larger experiment that adopted a novel approach using a battery of implicit tasks. However, due to the complexity of the experiment, we find it a crucial initial step to first explore, discuss, and report explicit responses to be able to relate the present study to previous ones with explicit assessments and to interpret any potential effects found through the reaction time paradigms. Although the explicit measures were not detailed in the preregistration, a general preference for curved over angular shapes was assumed, which would also be reflected in explicit rating differences of the stimulus material; i.e. higher aesthetic ratings, and lower stress as well as higher rest ratings for curved vs. angular stimuli.

All data analysis was conducted using R Studio—v1.4 Tiger Daylily (RStudio, Boston, MA, United States).

We split the analysis into three parts, matching the logic of our research questions, and following both a theory- and data-driven stepwise approach. The dependent variables (DVs) were participants' responses on the 0–100 VAS scales. Mean scores were assessed for each dependent variable (i.e., rating dimension) *via* repeated-measures analysis of variance (RM ANOVA). All analyses were controlled for repetitions within participants by means of the factor "subject."

We first conducted a manipulation check to test the contrast validity of our stimulus set (level 0). Thereby, to confirm the contour contrast was well discriminated within both styles, participants' ratings on "edginess" and "roundness" were analyzed separately following two 2 (contour: angular vs. curved) × 2 (style: classic vs. modern) repeated-measures ANOVAs. One dataset was excluded from the analysis due to missing values ($N = 197$ subjects included), and a total of 788 observations (197 participants × 4 images) were included in the analysis of each of the two rating scales (total = 1,576 data points).

For the main analyses, we conducted four two-way repeated measures ANOVA for each of the rating dimensions of the ASR scale to compare the main effects of contours (angular vs. curved) and style (classic vs. modern) as within-subject factors [IVs], as well as their interaction effects on the aesthetic (beauty, liking) and stress (rest, stress) response rating scores [DV] (level 1). Although we were interested in the overall response to the rooms rather than to each individual frame, we did not aggregate scores across perspectives prior to conducting the tests, and total of 3,960 data points were included in each of the four models (198 participants × 20 images). Since the effect of style exclusively was not part of the research questions addressed in this paper, related main effect analyses are briefly described within the manuscript (but are included in detail in Supplementary Table 9).

In the following step, and as we intended to examine potential sex differences (see introduction section for details), we conducted separate mixed ANOVAS for each of the dimensions of the ASR, with contours (angular vs. curved) as a within-subjects factor and sex as a between-subjects factor and as moderator variable [i.e., interaction effects]) (level 2).

For all models, we first report the main omnibus effects then interactions (with the respective descriptive statistics and effect sizes), each followed by the related pairwise comparisons on the different stimulus factors corrected using the False Discovery Rate method (FDR; Benjamini and Hochberg, 1995), along with effect sizes estimated by means of Cohen's d (Cohen, 1988). According to the commonly used interpretation, effect sizes are referred to as small ($d = 0.2$), medium ($d = 0.5$), or large ($d = 0.8$). We used the package "afex" (Singmann et al., 2022) to fit the models and produce inferential statistics, package "emmeans" (Lenth et al., 2022) for the pairwise comparisons, and package "effectsize" to compute Cohen's d values (Ben-Shachar et al., 2020).

Furthermore, we performed reliability analyses to check whether the ratings employed served as reliable measurement techniques for the aesthetic and stress responses to contours. For each of the rating scales, the different stimuli were regarded as "items" which were used to calculate Cronbach's α. As each image was repeated only once within each rating scale, every rating value was considered as one "item." Using function "cronbach.alpha" from the package "ltm" (Rizopoulos, 2022), Cronbach's α was calculated separately for each group of stimuli that we expected to produce similar explicit response (separately for each of the four combinations resulting from the 2×2 design).

Results

Manipulation check – Level 0

Results of the manipulation check (level 0) confirmed a highly significant main effect of contours on both *edginess* [$F(1, 196) = 2567.11$, $p < 0.001$, $\eta^2_g = 0.83$) and *roundness* [$F(1,196) = 2173.42$, $p < 0.001$, $\eta^2_g = 0.82$] ratings. Pairwise comparisons showed that images of angular contours were rated as more *edgy* [$t(196) = 50.67$, $p < 0.001$, $d = 3.62$; $M = 88.96 \pm 11.22$] and less *round* [$t(196) = -46.62$, $p < 0.001$, $d = 3.33$; $M = 7.87 \pm 10.29$] than those of curved ones (*edginess*: $M = 18.81 \pm 14.68$; *roundness*: $M = 77.11 \pm 16$) with exceptionally large effect sizes.

Significant interactions of contours with style were observed within both *edginess* [$F(1,196) = 10.85$, $p = 0.001$, $\eta^2_g = 0.01$] and *roundness* [$F(1,196) = 10.15$, $p = 0.002$, $\eta^2_g = 0.01$] scales. Post-hoc comparisons revealed that while our sample rated the angular versions of the images equally among the two styles concerning both edginess and roundness, significant differences were observed between ratings of the curved versions when they were depicting a classic as opposed to modern style [*edginess:* $t(196) = -4.85$, $p < 0.001$, $d = 0.35$; *roundness:* $t(196) = 4.19$, $p < 0.001$, $d = 0.30$], whereby images of classic style were perceived as edgier and less round than their modern counterparts. However, effect sizes were small (*edginess*: $d = 0.35$; *roundness*: $d = 0.3$), and this did not substantially influence the effects of contour, which remained particularly significant for the two rating dimensions within both styles ($d > 2.78$ for all four comparisons) (see Supplementary Figure 1 for a graphical depiction of main effects of contour and the interaction with style, and Supplementary Tables 2–6 for further descriptives).

Aesthetic and stress response ratings (level 1)

Main effect of contours

The 2 (contour: angular vs. curved) × 2 (style: modern vs. classic) RM ANOVA confirmed a general main effect of contours on all four dimensions of the ASR: *beauty* [$F(1,197) = 10.09$, $p = 0.002$, $\eta^2_g = 0.01$], *liking* [$F(1,197) = 6.32$, $p = 0.013$, $\eta^2_g = 0.01$], *rest* [$F(1,197) = 99.18$, $p < 0.001$, $\eta^2_g = 0.12$], and *stress* [$F(1,197) = 63.80$, $p < 0.001$, $\eta^2_g = 0.08$].

Pairwise comparisons revealed that images of curved contours were rated significantly higher than those of angular ones on aesthetic preference scales with small effect sizes: *beauty* [$t(197) = -3.18$, $p = 0.002$, $d = 0.23$; curved: $M = 51.72 \pm 14.87$, angular: $M = 47.75 \pm 15.07$] and *liking* [$t(197) = -2.51$, $p = 0.01$, $d = 0.18$; curved: $M = 51.22 \pm 15.57$, angular: 47.68 ± 16.13]. Furthermore, in terms of stress response, images of curved contours scored higher on *rest* [$t(197) = -9.96$, $p < 0.001$, $d = 0.71$; curved: $M = 55.1 \pm 13.30$, angular: $M = 43.34 \pm 15.30$] and lower on *stress* [$t(197) = 7.99$, $p < 0.001$, $d = 0.57$;

curved: $M = 37.39 \pm 11.83$, angular: $M = 46.22 \pm 13.62$] when compared with images showing angular interiors, with medium effect sizes. Figure 3 depicts the results of the contour main effect (refer Supplementary Tables 7, 8 for further descriptives).

Main effect of style

The main effect of style was also significant for all the scales of the ASR (see Supplementary Figure 2 for a graphical depiction of main effects of style, and Supplementary Tables 7, 9 for complete inferential statistics and descriptives).

Interaction of contours × style

There was a statistically significant interaction of contours with style in all the ASR scales *beauty* [$F(1,197) = 24.78$, $p < 0.001$, $\eta^2_g = 0.01$], *liking* [$F(1,197) = 45.75$, $p < 0.001$, $\eta^2_g = 0.01$], *rest* [$F(1,197) = 85.25$, $p < 0.001$, $\eta^2_g = 0.02$], and *stress* [$F(1,197) = 24.89$, $p < 0.001$, $\eta^2_g = 0.01$]. Effects of contours as a function of style are shown in Figure 4 (refer to Supplementary Tables 7, 10, 11 for further descriptives).

Interestingly, in terms of "aesthetic preference", post-hoc pairwise comparisons revealed statistically significant differences with small effect size only within the *modern style*, whereby *beauty* [$t(197) = -5.21$, $p < 0.001$, $d = 0.37$] and *liking* [$t(197) = -5.07$, $p < 0.001$, $d = 0.36$] scores were significantly higher for curved conditions (*beauty*: $M = 55.82 \pm 16.06$; *liking*: $M = 56.66 \pm 16.87$) as opposed to angular ones (*beauty*: $M = 46.87 \pm 17.01$, *liking*: $M = 49.00 \pm 19.32$). No significant differences were observed between images of angular and curved contours within the *classic style* in any of the two scales ($p > 0.05$). Interestingly, although insignificant, the direction of the effect was reversed in *liking* ratings, with curved conditions scoring lower than angular ones within the classic style category (refer to Supplementary Tables 7, 10, 11 for further descriptives).

Conversely, concerning "stress response", significant differences were observed in *rest* and *stress* scores within both *modern* (medium to large effects) (*rest*: $t(197) = -12.95$, $p < 0.001$, $d = 0.92$; *stress*: $t(197) = 9.43$, $p < 0.001$, $d = 0.67$) and *classic* (small effects) (*rest*: $t(197) = -5.45$, $p < 0.001$, $d = 0.39$; *stress*: $t(197) = 4.90$, $p < 0.001$, $d = 0.35$) conditions. Within the *modern style*, images of curved contours were rated as more restful ($M = 59.33 \pm 14.07$) and less stressful ($M = 33.45 \pm 12.77$) when compared with those of angular ones (*rest*: $M = 42.90 \pm 16.79$; *stress*: $M = 45.03 \pm 15.13$). The same applied to the *classic style*, however, the magnitude of the effect was less pronounced (refer to Supplementary Tables 10, 11 for further descriptives).

Sex-related differences (level 2)

Aesthetic preference ratings

ANOVA results showed a statistically significant two-way interaction of sex and contours for the *beauty* [$F(1,196) = 10.27$, $p = 0.002$, $\eta^2_g = 0.02$] and *liking* [$F(1,196) = 8.7$, $p = 0.004$,

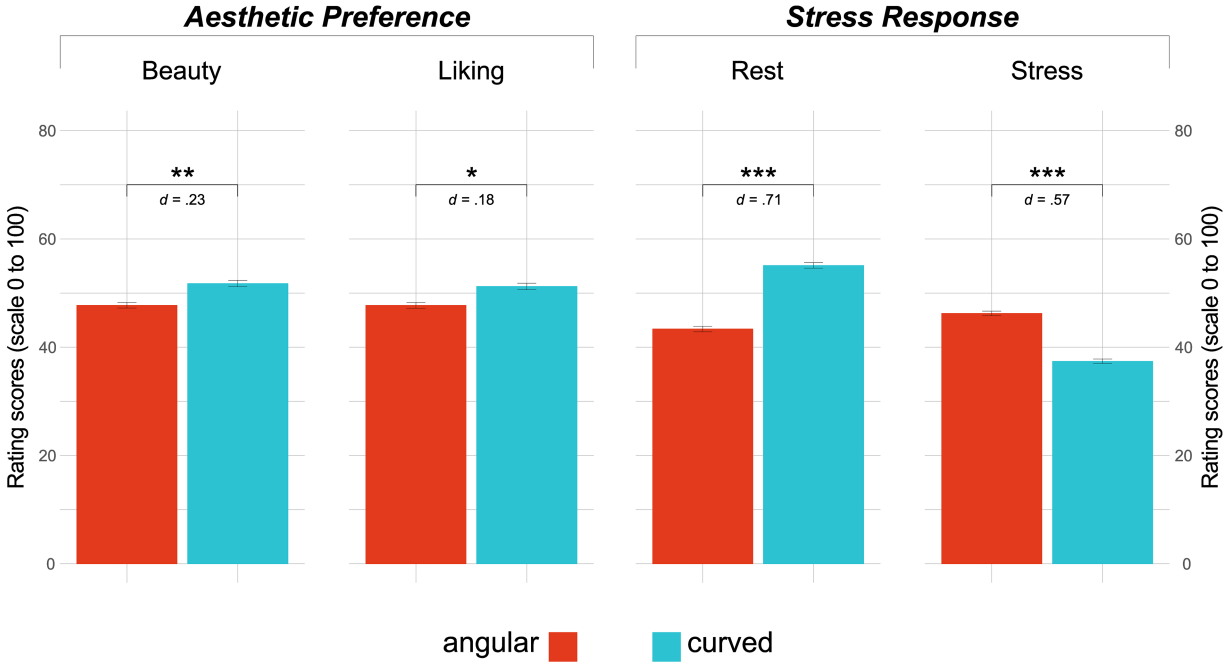

FIGURE 3
Contour main effect. Left to Right: Results of the analyses comparing mean scores of images of angular vs. curved interiors on the four rating scales representing "aesthetic preference" (*beauty* and *liking*) and "stress response" (*rest* and *stress*) evaluations. Scoring is on a range of 0–100. Bar graphs represent mean scores; error bars indicate standard errors. Asterisks represent significance, *p<0.05, **p<0.01, and *** p<0.001.

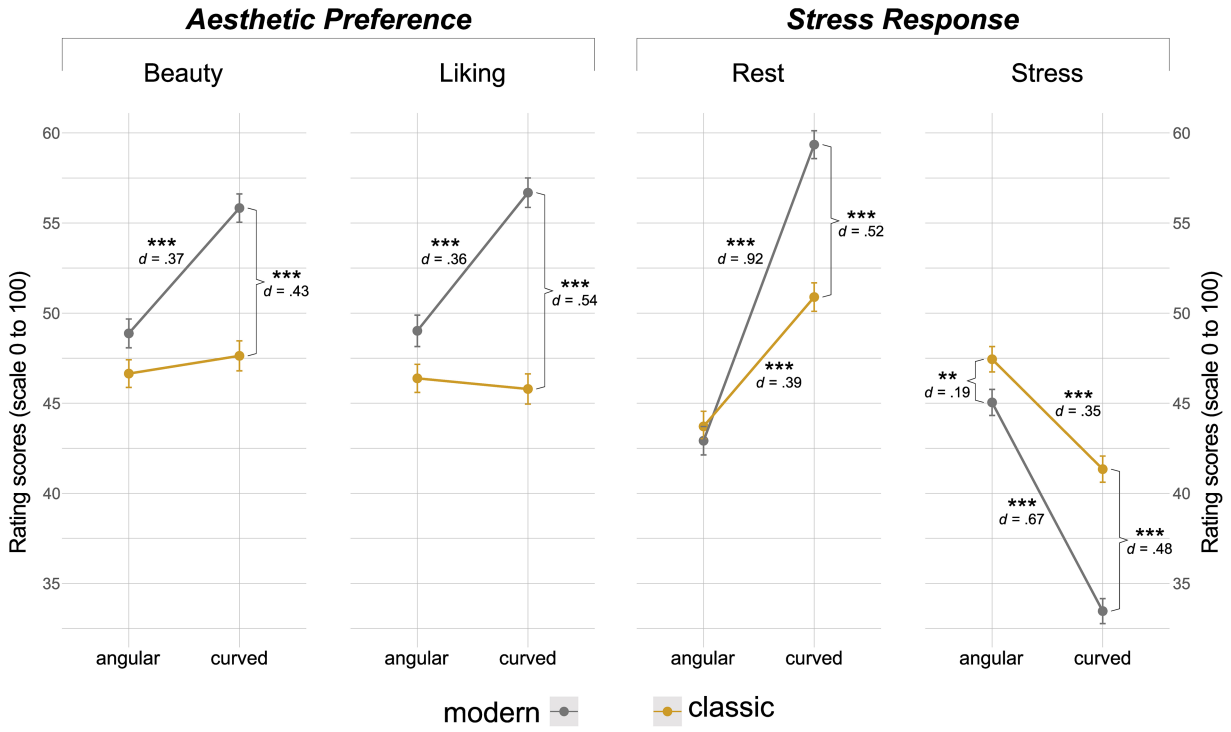

FIGURE 4
Contours and Style interaction. Left to right: Interaction plots depicting effects of contours, as a function of style, on each of the four rating scales representing "aesthetic preference" (*beauty* and *liking)* and "stress response" (*rest* and *emotion*) evaluations. Scoring is on a range of 0–100. Error bars represent means and standard errors. Lines do not indicate any temporal component between data points. Asterisks represent significance, *p<0.05, **p<0.01, and *** p<0.001.

$\eta^2_g = 0.02$] ratings (refer to Supplementary Table 12). Interestingly, post-hoc pairwise t-tests indicated that the positive effect of curved conditions was only significant and therewith mostly driven by participants who indicated their biological sex as female (referred to as female participants hereafter), who had rated images significantly higher on *beauty* [$t(196) = -4.56$, $p < 0.001$, $d = 0.33$] and *liking* [$t(196) = -3.90$, $p < 0.001$, $d = 0.28$] when they were showing curved (*beauty*: $M = 53.85 \pm 13.11$; *liking*: $M = 53.21 \pm 14.09$) as opposed to angular interiors (*beauty*: $M = 45.97 \pm 14.23$; *liking*: $M = 45.61 \pm 14.45$). There were no observed significant effects of contours on the preference ratings of participants who indicated male as their biological sex (referred to as male participants hereafter) ($p > 0.05$) (refer to Supplementary Tables 13, 14 for further descriptives).

Stress response ratings

Similar to preference measures, significant interactions of sex and contours were observed in both stress response ratings, namely *rest* [$F(1,196) = 11.2$, $p = 0.001$, $\eta^2_g = 0.02$] and *stress* [$F(1,196) = 6.06$, $p = 0.015$, $\eta^2_g = 0.01$]. However, in contrast with aesthetic preference, the positive effect of curved conditions was found to be significant in both sex groups, although with descriptively lower magnitude in male participants (refer to Supplementary Tables 13, 14 for complete inferential statistics and descriptives). Effects of contours as a function of sex (for both aesthetic preference and stress response) are shown in Figure 5.

Reliability analysis

The reliability analysis indicated acceptable to good internal consistencies among the different rating scales across all 20 respective stimuli within each of the four stimulus categories (i.e., Cronbach's α range for *beauty:* $0.80 < \alpha < 0.85$, *liking:* $0.8 < \alpha < 0.87$, *rest:* $0.74 < \alpha < 0.81$, and *stress:* $0.71 < \alpha < 0.81$). The results of the reliability calculations are presented in Table 2, along with the respective confidence intervals.

Discussion

In the previous literature, a positive effect of curved as opposed to angular stimuli has been empirically demonstrated, mostly in studies testing images of abstract shapes and (greyscale) everyday objects in different experimental paradigms. However, no consensus has yet been reached as to the source of this preference, with some scholars attributing the preference to attractive intrinsic properties of curves (Palumbo and Bertamini, 2016), while others proposed that it is caused by a possible sense

of "threat" elicited by angularity/edginess (Bar and Neta, 2006). A growing body of experimental literature has suggested similar effects in the context of interior spaces and architecture (Dazkir and Read, 2012; Vartanian et al., 2013; van Oel and van den Berkhof, 2013). To investigate this phenomenon in different psychological domains and further examine whether other stimulus- or person-related characteristics can interact with the effect (i.e., interior design style and reported biological sex), we measured the explicit responses to matching photo-realistic images exclusively contrasted in terms of contours (angular vs. curved) and interior design style (modern vs. classic), in a balanced sample in terms of sex ($N = 198$). Building on the evidence in the literature, we hypothesized a positive impact of curved contours on both explicit aesthetic and stress responses collected *via* ratings of beauty, liking, rest, and stress (higher beauty, liking, and rest, and lower stress).

The effects of contours on aesthetic preference ratings

In line with our hypothesis, our results revealed that contour was a significant predictor for the variability in aesthetic response ratings. The post-hoc results showed that participants, in general, preferred images of curved contours, as indicated by the higher ratings on the liking scale, and found them more beautiful than those showing angular ones. These results support previous findings (Bar and Neta, 2006; Dazkir and Read, 2012; Vartanian et al., 2013, 2019; van Oel and van den Berkhof, 2013) and provide additional evidence on the effects of contours on aesthetic evaluations.

Despite the statistically significant main effects of contours in explaining the variability of aesthetic preference ratings, the percentage of explained variance was considerably low (i.e., 1% for *beauty* and *liking*) suggesting that factors other than contours may play a stronger role in the aesthetic response. In fact, both objective (characteristics of stimuli) and subjective (characteristics of context) factors are proposed to be important in shaping aesthetic experiences (Chamberlain, 2022). In a recent meta-analysis, the first to inspect the consistency of the curvature preference hypothesis, factors other than perceptual contour properties were identified as moderators of the effect, namely, presentation time, stimulus type, expertise, and task (Chuquichambi et al., 2022, pre-print). The study found small to non-significant effects with spatial design stimuli as opposed to larger effects with meaningless or real object stimuli. It might be that the sensitivity to curves in architectural settings involves more complex processes influenced by familiarity, meaning/affordances, or other observer-related differences. Although

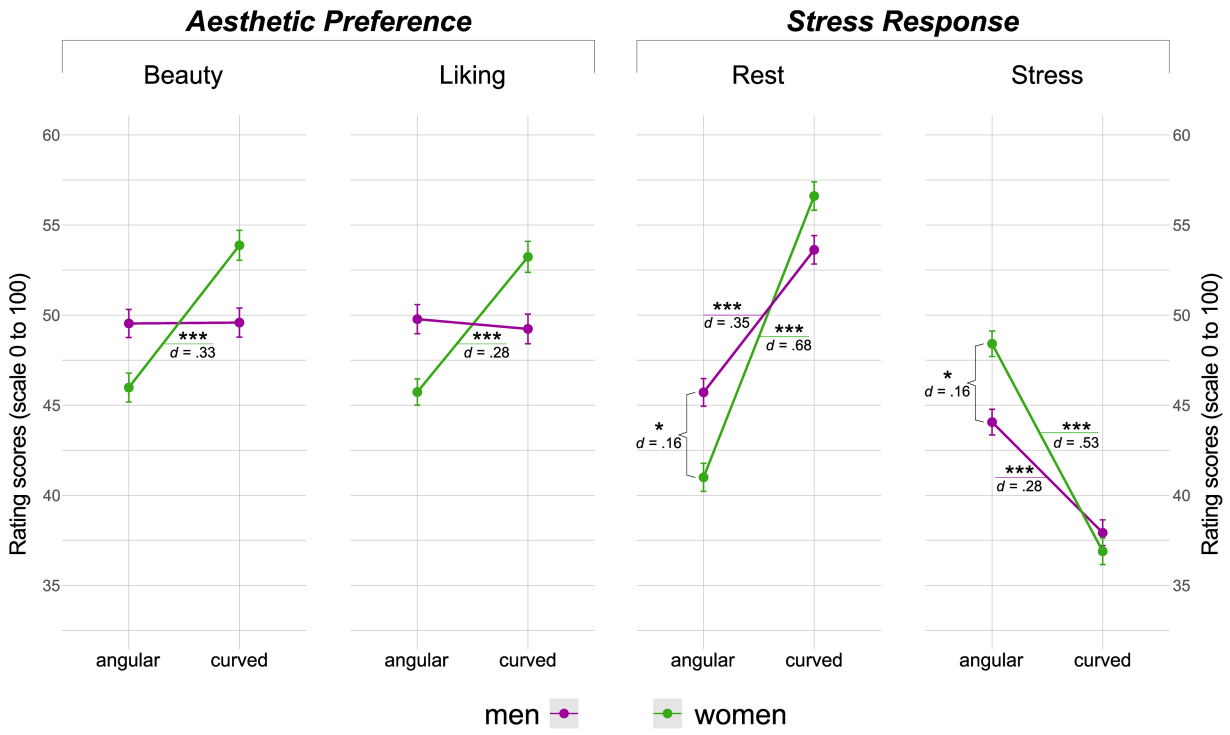

FIGURE 5
Contours and sex interaction. Left to right: Interaction plots depicting effects of contours, as a function of sex, on each of the four rating scales representing "aesthetic preference" (*beauty* and *liking)* and "stress response" (*rest* and *emotion)* evaluations. The terms "male" and "female" are used as grouping adjectives, as this was how participants were asked to (dichotomously) classify themselves. Scoring is on a range of 0–100. Error bars represent means and standard errors. Lines do not indicate any temporal component between data points. Asterisks represent significance, *p<0.05, **p<0.01, and *** p<0.001.

TABLE 2 Reliability of the rating scales (*N*=198), 5 items (5 picture per category AM, AC, CM, and CC).

	Beauty		Liking		Rest		Stress	
	Cronbach's α	CI	Cronbach's α	CI	Cronbach's α	CI	Cronbach's α	CI
Angular-modern (AM)	0.82	0.76–0.86	0.85	0.80–0.88	0.80	0.73–0.84	0.75	0.68–0.81
Angular-classic (AC)	0.83	0.78–0.86	0.84	0.79–0.88	0.80	0.74–0.84	0.78	0.72–0.83
Curved-modern (CM)	0.80	0.73–0.85	0.80	0.74–0.80	0.74	0.66–0.80	0.71	0.64–0.77
Curved classic (CC)	0.85	0.80–0.88	0.87	0.83–0.90	0.81	0.75–0.86	0.81	0.74–0.85

Bootstrap 95% confidence intervals (CI) based on 1,000 samples (2.5–97.5%).

we collected information on expertise, only 2.5% of our sample were identified as experts (had a training/profession in architecture/interior design), thereby not qualifying to run any moderation analyses.

Moreover, our results revealed a significant interaction effect between style and contours, confirming the idea of contextual factors other than contour shape *per se* influencing the evaluation. This is consistent with a previous study in which two pairs differing in their styles yielded significantly different self-reported pleasure and approach responses (Dazkir and Read, 2012). Interestingly, when looking at contours within each of the styles separately, results showed that the positive evaluation of curved versions on beauty and liking scales was conditional to the interiors belonging to the modern style, with no significant differences observed within the classic style category. This suggests that, although contours played a general role in aesthetic preference, the effect was dependent on other contextual factors, i.e., in this case style, which explained marginally larger proportions of variance (1 to 2%). Indeed, our sample preferred images of modern over classic style, and rated them significantly higher on the beauty and liking scales. The generally less favorable ratings of classic style might have affected scores and masked the contour-effects. At first glance, these results could be interpreted as being in accordance with previous findings which suggested that in addition to the proposed biological inclination towards curved objects, this preference could also be partly modulated by fashion, trends or Zeitgeist effects (Carbon, 2010). A confounding factor of time-specific preferences was suggested, since recent studies demonstrating a favoring of curved designs have been conducted in a period where curvature has been frequently used. Although we have not instructed our participants to evaluate the images as if they perceived them from a historical perspective, a similar Zeitgeist effect is to be expected when considering the style contrast of our stimulus set. However, the findings cannot confirm whether the observed effects strictly relate to time-specific aesthetics, or are rather the result of the generally negative appreciation of the classic category, or both, a question which would require investigating additional variations.

The effects of contours on stress response ratings

Generally, contour was a significant predictor of the variability in stress response ratings. Effects were robust and consistent. Pairwise comparisons showed that participants rated images of curved contours as more restful and less stressful than their angular counterparts. In line with previous findings (Madani Nejad, 2007; Dazkir and Read, 2012), our results provide evidence for the relaxing effect of curved contours in interior environments.

Contrary to the findings for aesthetic preference, the curvature positive effect was not dependent upon style, and the factor contour explained larger proportions of variance (8% for *rest* and 12% for *stress* as opposed to 1–2% in the case of aesthetic response). Although there was a significant interaction effect of contours with style, when examining the explicit stress response in rest and stress scales, curvature had a significant, similar positive effect on ratings in both interior design styles (i.e., higher rest and lower stress). The style comparisons showed that images depicting classic style were generally more negatively rated on both scales when compared to those belonging to the modern category, however, the contour effect remained significant. This suggests an overall stronger and more consistent effect of contours on stress response as compared to aesthetics, since stress-related findings "survived" the generally less favorable ratings of the classic style. With reference to the biophilia hypothesis and the deriving frameworks suggesting curvature as a biophilic asset in architecture and design (Kellert and Calabrese, 2015; Salingaros, 2015), it has been argued that nature commonly includes more curves than angles, therefore individuals are expected to be naturally drawn to curves (Salingaros, 2015; Coburn et al., 2019). Beyond exclusive preference, researchers have highlighted a role of curvature (and biophilic design *per*

se) in reducing physical (bodily) and psychological stress (Salingaros, 2015, 2019). Our results present first evidence for the relaxing effects of curvature within fully controlled, yet ecologically valid settings.

Sex-related differences

Aesthetic preference ratings

When looking into scores of both sex groups separately, we found a significant effect of the factor "sex" for explaining the variability of aesthetic preferences. Specifically, female participants generally liked images of curved contours more than those of angular ones and rated them higher on beauty, while no differences were observed in male participants' ratings on both scales. This finding is in line with re-emerging implicit evidence suggesting potential differences in the appreciation of contours observed with abstract stimuli (Palumbo et al., 2021) and virtual indoor environments (Tawil et al., 2021). In fact, earlier research had examined sex differences in preference and production of shapes, and had associated those with "sex-linked symbolic properties" of the stimuli (Munroe et al., 1976). The last study to report sex differences investigated wrapped candies in children (Munroe et al., 1976). Although generally children from both sex groups ($N = 175$) chose the spherical candy over the cube shaped one more frequently, girls chose it even significantly more than boys (83% vs. 57%). The authors linked the effect to one's conception of their own body, at least regarding objects to be ingested. However, considering the age range of the study population (4 to 12 years old), it could be argued that the results rather speak for "projected body ideals," as body curves of both male and female sexes are thought to be similar until teenage years. Associations between curvature and femininity were previously proposed in spatial design, whereas sketches of interior spaces were found to be rated higher on the "masculine-feminine" scale as levels of curvature increased (Madani Nejad, 2007). More recent works noted that the main portion of the evidence on the effects of contour in most domains generally stems from homogeneous samples (i.e., female psychology students) (Palumbo et al., 2020), and indeed, a subsequent study observed a stronger preference for meaningless curves within this specific population (Palumbo et al., 2021). The findings were interpreted as evidence that the preference for curves has both social and biological roots. Generally, it has been suggested that men and women vary in how they respond to aesthetics (Djamasbi et al., 2007). Such differences could be related to social norms and gender stereotypes, but also to more biological sex differences (Lueptow et al., 1995). Biologically, sex-related differences in the neural correlate of beauty have been previously demonstrated, with the observed different strategies used for assessing aesthetics attributed to a division of labor between male and female hunter-gatherer hominin ancestors (Cela-Conde et al., 2009). Although our results present the first confirmatory evidence on sex-related differences in the aesthetic preference of curved interiors, the findings do not allow to discriminate whether these effects are sex- or gender-related. Since our sample reported on biological sex, we are using the term "sex," however, further research is needed to clarify whether these effects result from social constructs related to gender, or are rather intrinsic.

Stress response ratings

Conversely, in terms of stress response, our results showed that the factor "sex" did not have a substantial effect on the significance of any of the ratings scores on rest and stress dimensions. Both sex groups rated images of curved contours higher on rest and lower on stress when compared with those showing angular ones. However, the magnitude of the effect was descriptively higher in the female as opposed to male subgroup. Overall however, we observed more consistent effects than in aesthetic preference ratings, with larger effect sizes. The results imply that contours could have a more global effect on the explicit stress response. When comparing the ratings of the two subgroups within each contour category, descriptively, female participants rated images of angular contours more negatively, and those of curved contours more positively when compared with male participants. However, the differences only reached significance in the case of angularity, specifically in both stress response ratings.

In sum, whereas curvature was found to be aesthetically preferred over angularity, this explicit preference was conditioned by the factors "style" and "sex." In contrast, curvature's positive effects on explicit stress responses were not dependent on other stimulus- (i.e., style) or individual (i.e., sex-related) factors. The amount of explained variance by contour was considerably higher for stress as opposed to only small amounts explained for aesthetics. Moreover, post-hoc results showed small effect sizes in aesthetic preference ratings compared to those found in the stress response evaluations (medium to large effects). We interpret the independence of the curvature positive effect on the stress responses from context (style) and reported biological sex as hinting towards a generalized, hence perhaps adaptive, phenomenon. Future efforts could examine more implicit mechanisms that present objective indicators of a stress-reduction effect.

Before concluding our discussion, it is worth mentioning that although we observed an effect of curvature when presenting two-dimensional static images of the rooms, the same environments experienced in 3D and in real human scale *via* immersion in VR did not elicit any differences on a large set of affective and cognitive measures, including similar ratings as in the present study. VR has been proposed as an alternative to the costly real life setups, as it allows the manipulation and control of relevant experimental parameters (Franz et al., 2005), while providing the opportunity to enable a feeling of presence in a space, evoking responses that are similar to those elicited

by real environments (Bishop and Rohrmann, 2003; Villa and Labayrade, 2012). This is particularly important within the increasing acknowledgement of the role of the body in the architectural experience (Spence, 2020). The present findings reiterate previous concerns as to whether environments affect us in the same way, or ultimately differently, when being inside them as opposed to looking at their image (Nasar, 1994). Although we are not able to directly compare the present results with the ones from our previous study, it is necessary to further explore and compare the curvature effect on the psychological and physiological responses within different presentation modes.

Limitations and directions for future research

Overall, this paper is far from providing decisive directions, as our current results are limited to explicit responses collected through self-reports, thereby lacking the objectivity required to draw affirmative conclusions. Although our measures lacked a common operationalization of such assessments, we were able to draw initial differentiation on the effects of contour on two different psychological domains that hypothetically operate through different mechanisms. Here, it is worth noting that Cronbach's coefficients confirmed the reliability of our measures, as they revealed good levels of internal consistencies, especially when considering the low number of "items" (5 items by category). However, given the high cross-correlations between all four rating dimensions (refer to Supplementary Table 15), further research is needed to define the most relevant factors when it comes to rating subjective responses to interior design stimuli, particularly in terms of psychometric scale development. Concerning the results, albeit effects were statistically significant, a small variance was found to be explained by our manipulated factors (contours, style). This implies that other factors may play a stronger role in the aesthetic and affective response variability. Given the complexity of environmental influences, with the present study only tapping into a few aspects of the visual domain, this is somewhat unsurprising. In addition, considering the acknowledged role of affect and/ or inter-individual differences in influencing the response to physical environments, future studies could balance their designs to account for variables such as mood, psychopathology, personality traits, and expertise, among others. As we asked our participants to report on their biological sex and did not assess sociological gender, we are unable to interpret whether the observed effects were the result of sex- or gender-related differences. However, we regard this issue critically and highlight the need to explore such effects beyond the limited perspective provided by the traditional binary definitions. Future works should assess gender identity together with biological sex (e.g., since birth) in a more differentiated way. Although our sample was considerably large when compared to similar studies, the fact that our participants were recruited online may affect the sample representation of a more general population, i.e., the sample was highly educated. Last but not least, with the absence of strong theoretical explanations – which presents one of the main challenges of the emerging fields investigating the psychological impact of architecture and design (Higuera-Trujillo et al., 2021) – it remains necessary to further explore these tendencies within different presentation modes, and with more objective paradigms that can better detect potential adaptive and unconscious responses and indicate more robust evidence on any source of this phenomenon.

Conclusions

In sum, the present study found differential evidence concerning aesthetic preference and stress response to contours in interior environments. On the one hand, the positive appreciation (beauty, liking) of curved compared to angular contours was found to be context (style) and sex-dependent (i.e., only in modern style, and only in participants who indicated female being their biological sex), suggesting that explicit aesthetic evaluations may vary meaningfully as a function of inter-individual and contextual (perhaps Zeitgeist) effects. On the other hand, the negative effects of angularity and edges on the stress responses (lower rest and higher stress), operationalized to resemble basic physiological/ affective states that may be triggered by environmental contexts, were robust, larger in magnitude, and not style or sex-dependent, also proposing a potentially adaptive response to curves, previously characterized as "biophilic." To the best of our knowledge, this is the first study that provides such evidence within fully-controlled yet ecologically valid settings (i.e., multiple photo-realistic images representing several perspectives of one space). Taken together, it could be speculated that the effects of contour in interior environments might be more generalizable with respect to psychological and physiological/ bodily responses than concerning the more conscious evaluations of aesthetics informed by experience and other cognitive mechanisms. Future works may want to focus on these dimensions which could be more relevant and especially important to informing designs intended for mental health promotion, however, using more implicit measures. On a last note, the significant results observed when presenting the same environments in the form of static stimuli (i.e., images, as opposed to VR immersion) raise the question of which exact role the modes of presentation and immersion play in aesthetic evaluations, stress, and other responses to contours and interior environments *per se* – a question which should be further followed upon.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/mfpk2/.

Ethics statement

The studies involving human participants were reviewed and approved by Local Psychological Ethics Committee of the psychosocial center at Medical Center Hamburg-Eppendorf (LPEK-0215). The patients/participants provided their written informed consent to participate in this study.

Author contributions

NT and LA developed the experimental design idea and setup under supervision of SK. NT designed and provided the design stimuli, pre-processed the data, performed the analysis under supervision of LA and SK, and wrote the original first draft of the manuscript. LA and SK edited the first and all subsequent drafts. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.933344/full#supplementary-material

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Sustainability pedagogy: Understanding, exploring and internalizing nature's complexity and coherence

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Online learning during the COVID-19 pandemic has affected student academic performance as well as mental, physical, and social wellbeing. During a lockdown at the University of Toronto in Canada (September 2020–April 2021), my students expressed an underlying sense of *monotony* yet *uncertainty*. I recalled a contrasting paradox from the teachings of Indigenous Cree on mental wellness in land-based experiences: a sense of *stimulation* and *security* that we can liken to variations of Appleton's prospect-refuge theory. I modified my *Environmental Science and Pathways to Sustainability* course to support stimulation and security through embodied, interactive pedagogy at student-selected individual field sites. My main goals were to (i) support student mental wellness and (ii) provide an alternative to experiential field trips for understanding and connecting with nature as an adaptive complex system. I prompted students with field activities contextualized by a course narrative that purposefully directed attention to nature through intrinsically motivated curiosity, exploration, and discovery; conditions more similar to evolutionary environments of adaptedness than "getting away" in passive retreats. Student weekly field observations and reflections culminated in a post-intervention Reflection Assignment (n=15) which became the bases of thematic and narrative analysis. Other assignments were added to my evaluation of complexity comprehension. The intervention successfully instilled security and stimulation *via* purpose-directed attention to different aspects of nature in the same setting followed by periods of knowledge integration. This empowered students with *sustainability mindsets* indicated by greater self-reported: sense of coherence, change agency, cognitive and affective restoration, nature connectedness, nature relatedness, social connectedness, and pro-environmental values. Assignments demonstrated an understanding of the environment as an adaptive complex system that was not present at the beginning of the course. Some students' self-construct adopted nature and its complexity, empowering them with greater trait resilience. This work speaks to opportunities for merging psychological restoration and analytical curricula by integrating cognitive and sensory meaningfulness in sustainability narratives. It asks scholars to reflect on how we operationalize foundational theories of Environmental Psychology based on ancestral survival conditions and encourages empirical research to consider how sociocultural contexts can direct attention to nature through purposeful inquiry.

KEYWORDS

sustainability pedagogy, Restoration Theory, directed attention, complexity, resilience, pandemic, nature immersion, agency

Introduction

During the COVID-19 pandemic, university students experienced a deterioration in wellbeing correlating with lockdown severity (Rogowska et al., 2020; Wang et al., 2020; Szczepańska and Pietrzyka, 2021). Among US university students, less screen time (<8 h/d) and more outdoor time (≥2 h/d) buffered against numerous negative psychological impacts of COVID, including stress and preoccupation with the virus (Browning et al., 2021). In response to restrictions on social gathering, university instructors have been nudged to move the classroom outdoors, simultaneously taking advantage of the known nature-immersion benefits on student learning and wellbeing (Ayotte-Beaudet et al., 2020; Brookfield, 2021).

Outdoor pedagogies are very common in child and youth education, as in ecoschools, open schools, forest schools, or the Danish "Udeskole" (Bentsen et al., 2018). While outdoor education is gaining importance at the university level with sustainability priorities, it remains relatively uncommon due to a history of being physically and conceptually separate from "real" curriculum (Brookes, 1989; Lugg, 2007). We still tend to see more focus on non-academic recreation and leisure as restorative getaways from real work (Andre et al., 2017; Davidson and Ewert, 2020). While university environmental sciences often provide abundant outdoor learning opportunities, they tend to focus on "hard" analytical skills and the pedagogical research lacks attention to the cognitive, affective, and social dynamics that take place. Thus, we see a gap between university pedagogies, outdoor education, and Environmental Psychology.

This separation of nature-based activities from daily routine is a product of the post-industrial modern period. Blühdorn (2016) aptly summarizes how the modern individual has become alienated from social and ecological relationships once fostered in collectivist, land-based societies, is more subject to accelerated change (information, transportation, virtualization), and is thus more individualized, extended, and differentiated; further, that this is inextricably linked to our present socio-ecological crises. Along with Payne and Wattchow (2009), I believe this is reinforced in conventional higher education, where learning is a disembodied experience of siloed specialization, isolated from corporal and interconnected realities. These limitations are compounded with social isolation and virtual dependence of pandemic lockdowns.

Sustainability mindsets

How do we prepare environment and sustainability students with the personal and professional capacity to address human-nature devastation on Earth? As people who are deeply aware of this crisis and engaged in trying to solve it, these students are at greater risk of psychological distress and becoming paralyzed by anxiety, despair, and powerlessness (Fraser et al., 2013; Wallace et al., 2020).

Nature-immersion pedagogies can support these students by empowering them with applied field skills and mutually reinforcing traits of nature connectedness, psychological wellbeing, and pro-environmental values (Nisbet et al., 2011; Redondo et al., 2021). Yet necessary change cannot be addressed by simply caring about or measuring the environment; sustainability challenges must be approached with multiple worldviews in place-based, sociocultural contexts, and require interdisciplinarity literacy (Dale and Newman, 2005; Loring, 2020). Outdoor sustainability education is formative in traits of social conscientiousness, self-esteem, self-discipline (Torkos, 2017), and change agency (Irwin, 2010) that are necessary for organizational change. Sandell and Öhman (2010) specify that nature must be experienced in relation to ethical and sociocultural contexts and understood as a dynamic, process-oriented concept.

This concept, known as adaptive complex systems, is promoted as a theoretical framework supporting mutual human-nature *thriving* (Du Plessis and Brandon, 2015; Loring, 2020). Davis et al. (2018) define an adaptive complex system as a dynamic whole that is more than the sum of interdependent parts. Their research has demonstrated that university students who are systems thinkers have stronger understanding of complex ecological systems and their influence on socioeconomic domains; nature connectedness; social empathy; pro-environmental values and behaviors; and tolerance for ambiguity (Trovarello and Stroink, 2015; Davis and Stroink, 2016; Davis et al., 2018). Training students to think in terms of complexity alone may be a powerful tool for developing sustainability mindsets, and responding to uncertainty, stress, and isolation.

A critical aspect of human psychological *thriving* is a sense of coherence—the *enduring* yet *dynamic* sense that stimuli of both the *internal and external* environment have the three dimensions of comprehensibility, manageability, and meaningfulness (Antonovsky, 1996; Vinje et al., 2017). Consider the impact of ecoanxieties about distal and often intangible phenomenon beyond our individual control. Our understanding of sense of coherence can play an important role in educating healthy and impactful sustainability leaders, yet research at this intersection has not been explored.

Purpose-directed attention

Decades of research in Environmental Psychology has supported the theory that nature can restore our cognitive and

affective capacities after they are depleted by urban stressors. This work is built upon an underlying Evolutionary Psychology theory that our ancestral psycho-physiological systems evolved to handle survival challenges of natural settings in our *Evolutionary Environment of Adaptedness* (EEA; Tooby and Cosmides, 1990): relatively foreign modern environments can present a discord or mismatch unsuitable for our mind-bodies can be relieved by nature experiences (Kaplan and Kaplan, 1989: 73, 95; Joye, 2007; Grinde and Patil, 2009).

The mechanism of affective restoration offered by the *Stress Recovery Theory* of Ulrich et al. (1991) is based on automatic and unconscious attention to nature's beauty as an escape from daily demands. The Kaplans' *Attention Restoration Theory* proposes that modern settings deplete attentional stores through *forced*, *directed* attention on *mundane* tasks; cognitive restoration occurs in nature because it has the attributes of being safe, interesting, and "away from daily demands," inspiring a *soft, effortless fascination* and undirected (involuntary) attention (Kaplan and Kaplan, 1989; Kaplan, 1995).[1] However, these explanations ignore the fact our EEA did not separate nature from daily routine. Dualities of urban-nature, human-wilderness, and recreation-routine are modern constructs. Others have recently argued that land-based survival obviously demands ongoing, effortful attention and hard fascination (Joye and Dewitte, 2018).

Indigenous Cree harvesters (James Bay, Canada) shared with me that land-based survival requires constant, careful attention to changing patterns, symbols, and relationships in order to predict survival challenges and opportunities (*in progress*); moreover, survival is navigated through shared sociocultural meaning and a nature-based identity (Adelson, 2000; Grey and Patel, 2015). As such, Cree expressed that attention to these challenges, patterns, and relationships is intrinsically motivated (not forced) and enjoyable. I thus consider how to emulate this purposeful, semi-directed attention style in nature-based pedagogies.

Security and stimulation

I propose that nature settings offer cognitive and affective benefits insomuch as they provide security and stimulation. Again, I was inspired by Cree land-based practices, where the need to be prepared drives exploration and the joy of meaningful discovery. Understanding the environment fosters a sense of intimacy, trust, and safety, which helps cope with change and uncertainty.

This idea that the human psyche is enriched by natural settings with a balance of security and stimulation is not new. It is also presented in Appleton's (1975) theory based on *prospect,* potential to obtain more information, and *refuge,* concealment for safety (Appleton, 1984), and Preference Matrix of Kaplan (1995) based on *understanding* and *exploring*: more specifically, desirable natural environments offer *coherence* and *legibility*—organized relationships and points of orientation—as well as *complexity* and *mystery*—opportunities for discovery.

However, I propose that when greater meaning is derived from nature (as in collective survival), security and stimulation permit and promote the purpose-directed attention described above. Further, this drives a cycle of curiosity, exploration, and discovery that generates more meaning and intimacy with the environment, and reduces attentional effort, thus reinforcing positive feedback toward purpose-directed attention, security and stimulation.

In a virtual, fast-paced world of monotonous uncertainty, detached from the social and natural relations of production that support our own survival, we have few reasons to be attentive to subtleties in nature. My pedagogical approach attempted to create purpose-directed attention to nature using field activities and supporting class narratives with the aim of drawing attention to nature's complexities while promoting sense of stability and joyful discovery.

Theoretical framework

I have the following working theories which informed my pedagogical approach:

i. Interactive, embodied nature observation can harness our innate evolutionary need to derive psycho-social benefits from purposeful attention to nature; this is enhanced by integration periods of reflection and shared social experiences
ii. (Semi-) Directed attention in nature is intrinsically motivated when the information uncovered through discovery can be applied to a shared sociocultural narrative
iii. Revisiting a natural setting over time strengthens connection and comprehension of nature; along with gradual introduction of new information (changes in nature, exploration, sociocultural problem solving), it fosters a balance of security and stimulation that supports psychological thriving, this drives a cycle of further curiosity, exploration, discovery, and intimacy with the space
iv. Thus, sense of security/stimulation and purposeful (semi-) directed attention are mutually reinforced; focused and sustained attention is more restorative as trust and discovery increase
v. Sense of coherence with internal and external realities is strengthened through joint attention to meaningful sensory-perceptual-conceptual realities in a given moment; this reinforces the security/stimulation cycle above with greater agency and awareness

1 Kaplan and Kaplan (1989 p. 73, 95) acknowledged that ancestral attention would be influenced by acquiring food, cultural background and sense of belonging, yet these attributes are overshadowed by "getting way" in operational studies.

I did not empirically test these interacting theories in this retroactive study of secondary qualitative data. By presenting these theories congruently along with student testimony excerpts (Results), I hope to influence experimental design and emerging theory development in Environmental Psychology.

The case study

The intervention took place in a small first-year university *Environmental Science and Sustainability* course that prepares students for diverse programs of study across the humanities, social sciences, and physical sciences.[2]

My broader learning objectives when designing the course in 2018 were for students to develop (i) an understanding of, and connection to, the natural environment, (ii) a sustainability lens based on adaptive complex systems that they can apply to any discipline, and (iii) basic literacy, communication, analysis, and problem solving in environmental science situated in sociocultural contexts of sustainability. Prior to the pandemic, I used experiential pedagogy *via* field trips to natural areas, an ecological research station, campus garden spaces, farms, and sustainability organizations.

According to my students, these applied settings helped "non-science" majors better understand science and "science" majors better connect biophysical elements to subjective sociocultural contexts. Interdisciplinary majors were better able to see connections between disciplines and expressed reduced anxiety about taking on a program of study that carries more uncertainty, is less specialized, and does not have a defined career outcome.

The pandemic lockdown from September 2020 to April 2021 restricted this method. Moreover, students expressed feeling isolated, hopeless, and both a sense of anxiety due to uncertainty, as well as a sense of monotony due to lack of stimulation. Rather than reducing course work, I was inspired to change the qualitative features of student learning experiences in the form of the intervention.

Intervention objectives

I employed an outdoor intervention with the pedagogical goal of supporting student sustainability mindsets, including the following outcomes:

i. Standard course goals:

a. Introductory environmental science literacy and skills through experiential learning: comprehension, analysis, field observations, and communication
b. Embodied understanding of, and connection to, nature as a complex system
c. Understanding and application of adaptive complex systems of sustainability

ii. Mental wellness, social connectedness, and sense of security/stimulation during lockdown uncertainty, monotony, and isolation
iii. Sense of coherence—internal and external environments feel comprehensible, manageable, and meaningful—related to personal and environmental awareness and agency

I sought to support these outcomes by applying my Theoretical Framework above. I attempted to intrinsically motivate embodied and purpose-directed attention to novel entities and relationships in the same natural setting *via* meaningful course narratives (readings, discussion, field prompts, and online posts) that promote a cycle of curiosity, exploration, discovery, and nature connectedness, and support knowledge integration.

Methodological approach

The overall approach involved a nature-based intervention, weekly journal entries, and a final Reflection Assignment on participant experience that was used for data analysis. This Assignment, along with standard course assignments, was used to evaluate complexity comprehension and environmental perceptions. During the course, the students were not aware of my intervention strategy or the theory that informed it.

To develop the intervention, I applied the above theories in response to student needs, seasons, assignments, and coarse goals. Here, I share my broad strategies and provide select examples, but encourage readers to use their own variations of these strategies to best suit unique student populations, course goals, and disciplinary knowledge.

Weekly activities

Students chose a natural setting and a tree that would be accessible all year. For Weeks 2–8 of their first semester, they were instructed to:

- Complete readings on the weekly topic
- Conduct independent research that applies the topic to their setting or tree
- Follow "prompts" for field activities with their nature setting and/or tree
- Document observations in a field book (optional: personal journaling)
- Post photos of features that reflect the weekly topic (online discussion forum)

2 This course is situated in the Trinity One Butterfield Environment and Sustainability Stream of Trinity College, University of Toronto.

- Post key insights and answers to questions based on their readings, research, and observations (online discussion forum)
- Engage in seminar discussions about findings and experiences of field activities in the context of weekly topics

We explored topics such as ecology, evolution, conservation, invasive species, plant identification, phenology, hydrology, citizen science, soils, and anthropogenic change.

Strategies

Weekly activities permitted basic experiential learning and environmental analyses otherwise limited by the lockdown. I designed them with careful placement of continuity and novelty (security and stimulation) to simultaneously reduce lockdown distress, requiring no additional time commitment from students. Security and stimulation were fostered through new concepts or questions applied to the same space, or by returning to the same questions/concepts with different perspectives, in different seasons, or in an urban setting.

Weekly activity prompts and discussion questions required students to (i) discover their setting and tree to find answers, and in the process (ii) apply the course narrative (readings, independent research, and discussion questions) to their setting/tree, and vice versa. The meaning derived through this feedback over time was intended to foster greater connection to place and purpose-directed attention to novel entities and relationships in that place. I designed questions to intrinsically motivate discovery with their unique setting and tree, supporting skills in environmental science inquiry. Meaning, students were not given replicable, step-by-step instructions of what to look at; they were taught how to look for information and given questions that required careful observation (semi-directed attention). Application of field observations to class discussions and assignments gave students an opportunity to apply environmental science facts to place-based sociocultural contexts, seeing differences among their peers in unique ecological, geographical, and international settings.

Opportunities for social field work and shared navigation were extremely limited. Students connected over similar field experiences through the online discussion forum and online seminar. Posts of photos and findings were also intended to support social connection by sharing experiences through a familiar practice (i.e., social media).

I diversified the scope of attention and levels of engagement to introduce novelty and embodied interactions. I included more interactive tasks (e.g., digging and analyzing soil) and observations from different perspectives over time (e.g., factors in the environment that contribute to soil type), with different sensory experiences. Questions directed student attention to patterns of detailed features (e.g., leaf morphology) and broader systems (e.g., phenological change), as well as the relationships between features (e.g., mutualism and competition, invasive species traits, and root-fungal networks). My goals here were to encourage complex systems thinking by pivoting between reductionist and holistic scope of attention, thereby training mindsets that can place scientific facts in sociocultural contexts and overcome disciplinary conditioning in "science versus non-science" mindsets. To this end, I mixed analytical, creative, and reflection tasks, and had students consider this knowledge in immediate and distal contexts.

This practice was also intended to support their ability to see how life works on multiple scales, and to understand the ecological patterns of adaptive complex systems. Students were prompted to think of patterns of change based on interactions of features in the past, present, and future, as a place-based exercise in understanding anthropogenic change.

In Week 1, they were asked to write a definition of *environment*. By Week 2, they carefully observed their setting and tree, documenting the entities and interactions in this setting, and again defined *environment*. This was intended to contrast embodied and disembodied conceptions, to prime students for field observation, and to provide baseline notes of their perception, state, and beliefs while in their natural setting before diving into the material. Unlike past years, students were encouraged to use field books to free write about personal thoughts, feelings, and experiences. This gave them a needed emotional outlet and, by requiring students to reflect on these entries, facilitated an awareness practice on how external settings affect their internal states. Students had one undirected visit with the setting, taking notice of their observations and internal experience.

Post-intervention, students were asked to synthesize their nature observation experience by reviewing and reflecting on their journal entries (2–4 pages, plus images). They were given several prompts that involved analysis of their own entries, such as feelings in the setting; course material influence; urban/nature contrasts; changes in environment and self over time; undirected and directed attention contrasts; and impact of repeated visits over time. They were also asked to return to original definition of environment in their field book and reflect on how their experience affected the way they presently define and conceive of the environment (and, if relevant, other people and oneself). Last, they were asked to reflect on the overall experience and then comment on how (if relevant) the field activities influenced their COVID-19 lockdown experience.

Evaluation of outcomes

The Reflection Assignment was the central data source for evaluating intervention efficacy based on self-reported experiences and mindsets. Complexity comprehension was observed in definitions and conceptions of environment (pre- and-post-intervention). Standard course assignments were also used verify complexity comprehension: class discussions, an Ecohealth Report, and a Research Proposal. The latter two assignments require students to explore a specific environmental science topic

while situating it in sociocultural and economic domains of complex sustainability challenges, including concept maps.

The intervention was not a prepared experiment. It was triggered by a lockdown with uncertain and changing limitations. My decision to use assignments as data came retroactively when I observed the efficacy of this strategy among my students and saw how clearly the outcomes aligned with my theoretical predictions.

I used thematic analysis (Clarke et al., 2015) to deductively identify and code concepts, ideas, and terminology that reflect my objectives and working theory. I read the assignments repeatedly, each time revealing nuances to predetermined concepts and remained open to related yet unexpected themes. Given the storied nature of student personal reflections, I then viewed each as whole narratives of personal experiences, as in narrative analysis (Glover, 2013; Grimwood et al., 2018), seeing causal relationships between themes and participants, and inferring deeper meaning. I tracked thematic relationships using concept maps. I categorized themes (Results) as dominant patterns in the student experience; I include quotations in attempt to reflect lived experiences and interconnected themes, from which the reader may relate to or make further inferences.

I chose not to use participant names or labels to maintain anonymity of personal statements. Statements presented during class and in the Assignment could allow peers to link familiar concepts with personal reflections intended only for my eyes; the absence of labels decreased the likelihood of identification in a small course. Multiple excerpts were taken from each participant ($n = 15$) to reflect different perspectives and experiences.

Results

The results suggest that this pedagogical method supported student coping, comprehension, and sustainability mindsets during the pandemic lockdown. This is consistent with student sentiments made in class and at the end of the course. Coding uncovered major themes corresponding with their conception and connection to the environment, social connectedness, mental wellness, and a sense of security and stimulation promoted by purpose-directed attention (below), as well as indicators of course material comprehension and application, and the unprompted theme of time perception.

Overall, student testimonies supported my prediction that sense of security and stimulation was moderated by "purposeful" and (semi-)directed attention that became increasingly restorative with meaningful discovery and connectedness (Figure 1). Visits to familiar nature settings and trees (field sites) fostered a sense of security and emerging connection to nature. Course readings, discussions, and online posts prompted a positive anticipation to discover, helped students integrate observations, and enhanced their social connectedness. Students reported improved mental wellness as well as cognitive and affective restoration (immediately post nature). Embodied interactions during directed attention enhanced sense of agency, awareness, and coherence. Students developed stronger pro-environmental value and understanding of the environment as an adaptive complex system. Moreover, some students experienced an identity shift indicative of greater trait resilience: seeing self as part of nature and thus internalizing nature's adaptive, dynamic complexity. The following qualitative results include further inferences that will be expanded up on with other literature in the Discussion.

Environment: Concept and complexity

Students initially described *environment* (Week 1) as being relatively "stationary" or "fixed" with "easily defined boundaries." With recurring nature observations, they came to view the *natural environment* as "multiscaled," "interactive," "unbounded," and "dynamic" "parts that make up a whole." Several students noted greater "complexity" over time, which they claim would not be visible in one single visit. A student initially saw the environment "aesthetically," but by Week 3 they were paying attention to "patterns, clusters and arrangements." When comparing the built and natural settings, the former was characterized by "monotony," "uniformity," "manicured," and "conformity," and the latter with "diversity," "uniqueness," and "equilibrium."

Scientific and technical prompts initiated "intimate experiences" that led students to see trees as living beings that interact with their environment. This notion that their space was "alive" and "interactive" was often associated with phenological transformations, plant–animal interactions, and student-environment interactions. Students developed the sense that our environment is not a passage, but a living community that is responsive to us—that "humans can also communicate with nature." This interactive concept came full circle with the idea that the environment is "something we internalize," that we "can influence and be influenced by." Students claim the "hands on component" brought this interactive, living environment into a felt experience. It allowed them to see the "placement of plants in space" and watch them respond to weather over time. By digging through the layers of soil next to their tree, they better understood the ecological composition of their landscape and the patterns of relationship between these entities; they read about ecology in course materials, but live observations of one space allowed them to witness "an ecosystem in action."

Students also developed a more "multifaceted" perspective on what is included in our conception of *environment.* Original definitions were often constructed around a "wilderness" separate from their day-to-day and their own identities. Over time, this grew to include biotic and abiotic factors, built features, humans, and oneself. One student felt that urban settings "deceive us into perceiving environment as a separate entity." Time with their nature setting strengthened the sense that they are part of the "Earth" or "nature."

As a result, students' perception of humanity's position in relation to the environment also changed. For example, a student

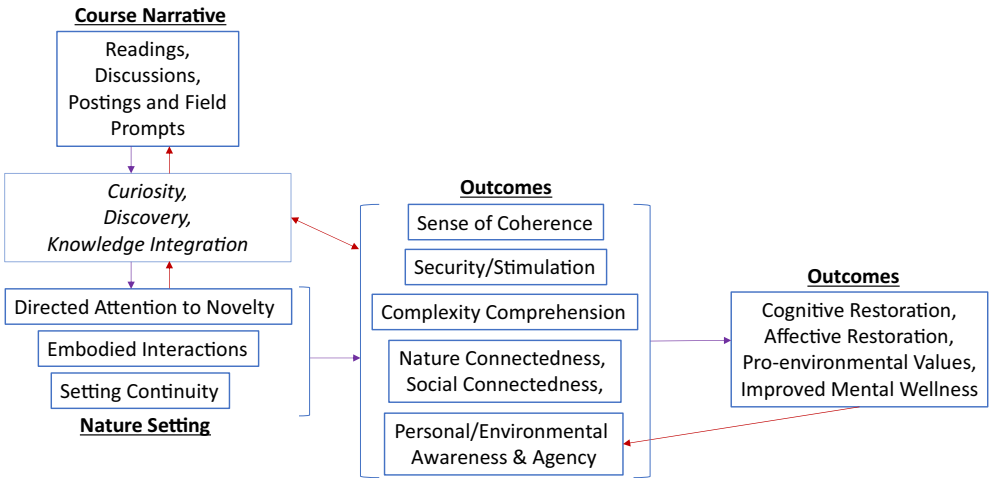

FIGURE 1
Self-reported outcomes of embodied and purpose-directed attention to a nature setting.

saw humanity as one small part of a bigger world that we are not in control of. Students left the course feeling nature was now more accessible, for example, including their own front yard. With the realization that nature "is always there," we do not need "a getaway," rather we can simply choose to connect with elements of the environment we are "present" with. When one student came to notice our lack of control over the natural environment, they had reduced anxieties around uncertainty. Ongoing observation of familiar, universal patterns of nature (discussed later in this section) gave a sense of consistency in the world, despite the fact that nature is changing and uncontrollable; this provided better sense of what they "can and cannot change."

Environment: Value and connection

With the perception of a "dynamic living" environment and humans as part of that environment, continuous visits nurtured intimate, familiar relationships: "I am part of the living system my tree is in." This was particularly powerful during a time of social isolation and indoor technological interfaces. One student stated that "paying attention to an individual tree actually created a sense of community." As their tree changed, they started to pay attention to "phenological rhythm" of other trees, who then became "recognizable characters" around the tree.

The ensuing "personal connection" to nature meant they no longer felt entitled to "exploit" or "profit" from it. In the second semester, one student expressed grief that their trees would be cut down: "I had observed the trees for almost 5 months and [reconnected with them since childhood]. They felt as much a part of me as the veins in my body."

A greater awareness of their surroundings was accompanied by awareness of our environmental impact and more "eco-conscious" behaviors. They watched the ground being shaped by travel, the movement of litter, and the management of plants. Along with a self-construct embedded in the natural world, this felt sense led to the idea that everyday actions are meaningful and, for at least one student, inspired changes in their everyday habits. In a similar case, it inspired a sense of urgency toward environmental stewardship that paralleled optimism and greater tolerance for ambiguity—the student began to see the "lockdown" constraints as temporary and, relatively speaking, that our "planet is not." As described above, while students consistently came to see the natural world as uncontrollable, they simultaneously saw human interaction with the environment as influential and meaningful.

All students felt the outdoor activity gave them a "new found" love of nature, also referred to as an "awakening" or being "reborn." By experiencing and reflecting on their psychological restoration in nature, students claimed to be more aware of nature's value to human psyche, and thus realized "what is lost when we live without it."

Security and stimulation

Habitual visits to familiar nature settings and trees fostered a sense of security: a "constant though the chaos of covid." Students described their space with terms such as "stability," "consistency," "welcoming," "comforting," "familiar," "haven" or "my space," and feelings like "whole and safe." The familiarity was afforded by space continuity and emerging sense of connection. Students developed curiosity about their space which sparked a needed sense of "wonder" and "creativity." They visited it in their free time to exercise or look for new discoveries. By the second semester, some students were driven to independently explore other natural areas near their home and became more familiar with their city.

Course readings and independent research prompted curiosity that could be "satiated" through field activities. For one student, "the more I learned, the more I wondered" and as a result,

"my tree gained importance." For other students, course teachings led to more "appreciation" of these settings, and in turn, a "gradual process" of connection to nature made the course readings "more personal."

For several students, initial field observations felt "felt like a chore," a "tedious process," or distraction from an "immense workload." One student, who had watched this "mundane" natural setting over several years, likened this experience to piano lessons: by being "motivated to do it externally, it eventually became a treasured part of my life routine…something I looked forward to doing, a reprieve from the monotonous rigor of everything else in my life." Another student also found the practice "quite mundane in that I had seen the same tree for about 10 years." With "prolonged periods of time…monotony turned to intrigue" because the "scientific knowledge" of forest ecosystems, invasive species, and environmental management became "remarkably interesting when I was able to point out new aspects of my tree and understand them."

All students expressed a positive anticipation for arriving in their space—"eager, keen, and excited to visit the same spot each week"—emotions remarkably absent from online learning and lockdown inconsistencies. They enjoyed awaiting birdsong, seasonal shifts, and returning animals. For some, this was carried forward as a generally positive outlook for the day ahead.

Although the prompts and nature itself were changing, nature became something fundamentally reliable: it was "comforting to know that nature often works in similar and predictable ways." Universal sense experiences of a breeze, smell of leaves after rain, or birdsong, were expressed as a constant over time and place. This was most appreciated by international students isolated on campus away from home: "I took solace in what remained unchanged… there were moments among the trees that I was separate from an unpredictable urban life and I could be certain about things."

The built environment had the opposite effect. Sounds were "constant but unpredictable" and sense of imagination and comfort were lost "due to calculated structure." This paradox was apparent in Covid-related anxieties—feeling "exposed" and yet "claustrophobic." In contrast, outdoor visits became a symbol of safety and freedom: protection among the trees, and yet the ability to discover "without restriction." In other words, "complexity and perpetuity of nature's cycles inspired me as much as it calmed me."

Purpose-directed attention

Student testimonies supported my prediction that this sense of security and stimulation was moderated by "purposeful" and (semi-)directed attention that became increasingly interesting and restorative with meaningful discovery. Students described their attention as more "specific," "scientific and "nuanced" over time, as if viewing the world in "higher resolution." Spotting "new" and "small details" each visit was supported by "encountering the same space every week." It stimulated an appreciation of nature's "complexity" and a sense of satisfaction from discovery. Attention to detail was, by student accounts, afforded by "purposeful" course material and directed attentional prompts. Referring to phenology, a student said, "I learned to pay attention because of the course material." For another, "it was only after reading about soil in our textbook that I could make in-depth observations." The impact on one student was a shift from focusing on "major cumulative changes" (like seasonal transitions of a forest) to noticing "smaller changes in individual trees."

Students made subtle discoveries in highly urbanized settings. Feeling stunted in a relatively sterile urban yard of Dubai, a student was inspired by learning that trees increase biodiversity acting as habitat and food; they decided to "pay more attention… notic[ing] many insects such as ants over the bark…and cicadas that formed a constant background noise…*Instead of a single tree, I saw it as a bustling microcosm full of life*." Another student similarly came to see their tree as "home to the living organisms in its personal ecosystem, such as the wasps' nest perched on its branch and the insects residing at its roots."

Appreciation for detail and emerging curiosity was afforded by embodied experiential learning, including their ability to enter spaces, interact with them, and look at living things from "different angles" than they normally would. Students reported enhanced sensory awareness to aspects of the natural environment that typically go "unnoticed." They explicitly noticed that engaging with the environment helps us be more aware of it: "to feel the texture of the dry and hard leaf…smell the dirt in which it landed in with the wind…we make contact…we develop feelings for it. We love it so much."

Beyond the course, students carried an ongoing "general awareness" of their surroundings and how they are internalized. After the first term, one student began to "make a conscious effort to take notice when I am in nature. I am aware of my senses as I watch the birds fly overhead, feel the wind and rain on my face, and listen to the rustle of squirrels in the trees." Students claim that attentional prompts and journal reflections gave rise to a "more conscious effort to be aware" of these interactions. A student gave the example of going into new settings being more aware of not only visible plant life, but also feeling "mobile forces such as the wind against my skin and how it could be carrying seeds and insects. The stationary, fixed environment I once appreciated in lifeless photos has now bred life and movement with bounds undefined."

Students independently identified benchmarks to measure subtle changes in their settings over time. For example, one student used a rock as an indicator of changing water levels in a creek. Setting continuity provided recurring features as markers of ecosystem changes and interactions, supporting field observation skills that are not easily established in a fast-paced, technocentric world. In fact, students felt that being away from technology in and of itself was a major factor permitting more attention to their surroundings and establishing this as a life skill.

While student observations increased in specificity, they did so without losing attention to the community as a whole. As shown above, students had greater sensitivity to interactions

between entities that made up their surroundings. Overall, they gave more attention to subtle changes over time without isolating entities of the environment from meaningful relationships. One student described paying new attention to details of leaf shape and bark texture, then "over time analyzing the environment surrounding my tree and how that would affect its development," and then extending this to surrounding urban development.

During the undirected attentional prompt, students reported that they initially focused on features from previous activities. Eventually, students let their mind "wander," extending observations to other features and interactions. One student reported more attention to the "overall environment" when left undirected. Another felt "lost yet bonded to nature."

Social connection

Despite extremely limited opportunities for social exchange, this approach seemed to have a positive impact on student social relations and sense of social connectedness during the lockdown. They bonded over a unique experience and sharing stories through common experiences, disciplinary vocabulary, and narratives of the course.

Weekly activities influenced social relations outside of our group; sharing discoveries with family members, or feeling connected to ancestors associated with the space. For some students isolated on campus, flora and fauna replaced a social community. They commonly spoke about their tree in a personified manner, and some made regular visit to their "old friend."

Students made interesting observations of social interactions in built and natural settings that enhanced their appreciation of nature as a social moderator. They noted a greater sense of community and connectedness among strangers in public nature settings (like parks) in comparison to the "colder" social structures of built settings. With "eyes drawn downward," urban environments were described as channels of transportation that "have almost made us as humans lonelier and more disconnected." Even when people were not engaging directly in nature, they shared joint attention "engaging in the same beautiful scenery together."

Students themselves felt it was more socially acceptable to pause, observe and socialize when in nature. In the built environment, "I felt uncomfortable in my own skin, as if I had to be busy or look occupied to other people. Yet in my nature spot I felt a sense of release." The student believed urban settings favored "progress and power," while nature provides an "organic sense of community and connectedness…that is so comforting…we are reminded that we are all a part of Earth."

Mental wellness

Mental wellness benefits came in the form of stress reduction, cognitive restoration, optimism, trait resiliency, self-discovery, and "healing." While some of these outcomes have been revealed above, I will present others, draw attention to moderators of these outcomes, and share student awareness and interpretations of these outcomes.

Mental wellness impacts of lockdown were expressed as feeling "confined and alone," "hopeless," "limited," "lonely," and "detached from reality," along with the "unhealthy patterns" of behavior. One student expressed it as "a collective experience that feels fundamentally singular…a societal grief with no reprieve."

Students consistently reported feeling less stressed after their visits, using terms such as "less anxious," "more relaxed," "joyful," "happy," "tranquil," "passion," "calmer," "warmer," "lighter," "healthier," and "serenity." They felt a sense of "companionship," "comfort," and "passion" absent from online learning. One student shared that, "going to my nature spot gave me a sense of control in my life when it felt like I had no control over any circumstances;" another felt "truly at peace" in the setting despite "uncertain times." Even when away from this setting, students "took comfort" in knowing they could return to nature when feeling "burned out" or "overwhelmed." Another found "peace of mind that no other place gave me."

Reflections also indicate cumulative and enduring impacts on student wellness over the course of the nature observations: "through this experience I have been able to find therapy and serenity through nature…in the past few months alone, my anxiety and other mental health issues have decreased."

It was common for students to feel heightened anxieties and discomfort during initial visits. For example, one student felt "anxious about the work I am putting on hold," but this dissipated once they started to "focus on the task at hand." Reflecting on weekly journal entries, one student noticed "unhealthy patterns of thought that began to shift," and another that their "tone became more positive." Learning about the natural world gave a student "a sense of purpose." Another student felt nature itself can "teach us joy and comfort." Nature's behavior taught a student how to not be "overwhelmed" and another how to adapt to disturbance.

Therapeutic effects were often phenomenologically based; meaning, the ability to interact with the setting was fundamental to coping outcomes. A student expressed that the pandemic isolation left them "trapped with my inner monologue"; nature observations helped this person "listen to what I could feel rather than my own thoughts. To embrace something external and receive new input." Feeling "connected" to the world, it "reignited an enthusiasm to be explorative and creative." Despite the scientific nature of most activities, an enhanced embodied awareness commonly followed experiences of positive emotions in their nature setting. Students communicated the disembodying effect of online, isolated learning with comments like: "the discourse between my mind and my body began to stagnate." Nature-based observations acted as a "grounding mechanism" that made them feel more "connected to reality" through hands-on activity in a time when "everything in my world was at a distance." For some, this was the ability to simply "breathe deeply again," "listen to what

I feel," or tap into the "organic sense of community and connectedness."

The awareness that we internalize our environment was realized through embodied experiences; students became "more aware of the healing power of nature" by spending "more time outside engaging with nature." They noticed how they internalized the sound of calm water or the relaxation that came from a "serene view." Recall simple sensory awareness, like the unsettling feeling from constant, unpredictable sounds of urbanicity. One student detailed how people in the built space seemed to be "reproducing aspects of [their] external environment. Like the gray rows above and the grids on the ground, their behavior was characterized by order, conformity and efficiency." Recall how built spaces made students feel the need to be busy and isolated; nature gave permission to be still, observe and engage with others.

Students experienced shifts in self-awareness, self-discovery, and identity. The impact of lockdown isolation, for one student, was a sense of "missing part of myself." A "nostalgic" desire to rebuild connection to nature once held in childhood was common, and it took form of a desire to reconnect with a past self. An unexpected outcome of the nature-immersion activities was that it helped some students "discover who I am," expressed also as a "sense of place," "peace, confidence and intimacy" with oneself. This self-discovery, as noted above in environmental constructs, emerged from a belief that we are part of nature and dependent on it: "it was in studying the intricacies of its branches, soil, and leaves over time that felt as if I discovered more about the features that make me who I am.

The self as part of nature had a "humbling effect," with a shift in perspective that we are but "one small part of a complex world." In turn, anxiety-inducing problems lost their significance. Connecting "with something greater" was both "humbling and exciting," and for some, fulfilled "spiritual needs." A spiritual "healing experience" was particular powerful for those who identify as "non-religious." A student in "desperate need of stability and healing" believed their tree brought healing through the ancestor who planted it: "ironically enough, as the leaves turned brittle and fell to the ground, my body and mind healed. It was almost as if the tree had given me its lifeforce as it entered its state of dormancy."

Awareness of nature's restorative capacities seemed to help students stay present with the activities, losing the idea that they were distracted from studying, and concluding that "time with nature is never time wasted." Students became increasingly aware of their enhanced cognitive performance after visiting their nature setting and, in turn, took away important lessons for balanced study practices. Further, time for "introspection" during nature visits or journal writing gave space for reflecting on who they are and how that aligns with how they spend their time and what they give their attention to. For example, "it was made clear to me that it was what you choose to focus on that can change, and it might change you." For some, this awareness encouraged healthier behaviors, as they found themselves exercising more and taking initiative to get outdoors.

Course goals and application

Consistent with previous years, students developed a greater capacity to make hypotheses about ecological interactions and causal relationships, and to think critically about complex socio-ecological systems. Assignments demonstrated the ability to apply observations of interconnectedness to interdisciplinary dimensions of sustainability. Reflection Assignments suggest that students were aware of this lesson, stating for example, that "as this course has progressed, my scientific knowledge of Earth's elements, anthropogenic influences, and multidisciplinary approaches…increased tremendously, [including] the interweaving of Earth science and political, social, and economic justice, with the goal of equality and sustainability."

Students reported benefits of science accessibility in applied settings with "kinesthetic and visual" learners being able to "touch and feel" at their own pace. A student stated: "I assumed I was someone who could never do science [but found] a new passion in the sciences that I could have never predicted." Students typically leave this course with greater curiosity about how the natural world works. Anecdotally, this year's cohort was extraordinary in their sense of nature connectedness, nature curiosity, and capacity to understand complexity.

Time perception

A recurring, unintended theme was a shift in sense of time. Several students noted they were initially unaware of how online learning was distorting their sense of time until they started working with the nature setting. A student described, "leaving technology behind when I visited my tree made time pass only as quickly as I felt it" and associated this with attention to embodied sensory experiences in the moment and reduced anxieties about the future – in turn, it restored their sense of "subjectivity" and they felt "more in control." Others became more aware of how fast nature could change, or how long it takes for leaves and acorns to fall.

Discussion

According to my students, nature-directed learning during the lockdown equipped them with a greater sense of connectedness and wellbeing, as well as sustainability mindsets, behaviors, and capacities. The preliminary results herein suggest these outcomes were supported by synergistic feedbacks between nature-immersion activities, course readings, discussions, assignments, and reflections.

Embodied engagement with nature played a significant role in the desired outcomes of this intervention – this is no surprise, given what we already know academically and intuitively about online learning and nature-immersion. The unique aspects of this work that I want to emphasize in this Discussion are the role of

curriculum—readings, discussions, assignments, inquiry/prompts, reflections, and overall narrative—and *setting continuity*. First, they have to capacity to support meaningful dialog between sensory/perceptual and conceptual/theoretical processing, which has outcomes on awareness, sense of coherence, and personal and environmental agency. The way nature is presented in the curriculum narrative thus has an important role in shaping what is internalized during this dialog. Second, they provide a needed freedom and structure, which, in conjunction with purpose-directed attention to nature, may enhance cognitive restoration, meaningfulness and sense of connection. Last, I highlight the role of collective and reflective knowledge integration in this process, particularly in sustainability-situated sciences, which can support profound shifts in how students perceive themselves, others, and the environment.

Scholars of "Place-Based" outdoor pedagogies examine the lived, embodied experiences that emerge from an *ongoing relationship* to a particular setting. They essentially apply the concept of place attachment—a bond formed between individuals and meaningful settings (Scannell and Gifford, 2010:1)—to pedagogy. Similar to my findings, place-based outdoor learning has helped youth apply knowledge to real-life challenges and understand social, cultural, economic, and physical interconnectedness in environmental decision making (Nielsen, 2016). Further, the "attentive connection" has a formative impact on sustainability identities, including greater care for the natural and human elements (Bates et al., 2019: 95). Attachment and meaning emerge over time as students "re-engage with "the active, perceiving, and sensuous corporeality of the human experience," also referred to as "ecocentric intercorporeality" (Payne and Wattchow, 2009: 16). Interpretations of the body, mind, and setting are harmonized into one coherent meaning-making reality. This emerging sense of coherent reality was common among my students.

Sensory-cognitive-setting connections were muted by lockdown learning, sitting in a chair, occupying the mind with abstract concepts unrelated to settings and sensations of their present realities. The associated distortion in sense of time expressed by my students is a common pandemic sentiment. We lack the ability to plan, maintain routine or experience normal temporal benchmarks of seasonal or annual gatherings, and we are isolated from people and places as they change. One study showed that, compared to urban settings, walking in nature slowed time perception and was accompanied by stress reduction and improved mood among university students (Davydenko and Peetz, 2017).

Payne and Wattchow (2009) suggest that such shifts in perceptions of time and space in place-based learning are facilitated by uniting of our sensory-perceptual and conceptual-theoretical processing. In other words, we are in "real time" when the theoretical concepts we are thinking about are enacted through our present embodied sensory experiences drawn from the present environmental setting. Nature activities restored sense of time, reality and awareness for my students as their mind and their body attended to the same environmental stimuli in a given moment. By paying attention to details and relationships of these living stimuli over several weeks, they could witness subtle changes in relation to time. Further, the meaning of sensory-stimuli interactions was enriched by these changes and course theory over time.

Based on this understanding, I want to highlight the importance of the conceptual course narrative in shaping how students conceive of nature, and thus, how they interpret their embodied nature observations and integrate them into meaning-making realities. Student sense of hopelessness, uncertainty, and lack of control subsided over the course; collectively, they related this not only to sensory awareness and connectedness, but also ongoing discovery of nature as interactive, dynamic, complex, self-inclusive, and responsive to their actions.

Our conceptual framework of nature, constructed in a given sociocultural context, is a lesser studied yet likely influential factor in the dynamics of nature connectedness, pro-environmental behavior, and psychological wellness. The framework for understanding environmental science and sustainability in this course was adaptive complex systems thinking: living entities interact, self-organize, and adapt to give rise to non-linear and unpredictable dynamics of evolution.

Leong et al. (2014) found that people with higher nature connectedness also tend to be more innovative and holistic thinkers, as measured by the Analysis-Holism Scale. The scale uses indicators of complexity reflected in student testimonies with statements like "the whole is greater than the sum of its parts." Recall how Mirella Stroink (see Introduction) has shown the compatibility of systems thinking with all the traits of sustainability mindsets as presented herein.

According to both Indigenous and Western scholars, complexity of nature is more easily understood when we are immersed in it and see ourselves as part of nature (Davis and Sumara, 2000; Salmón, 2000; Du Plessis and Brandon, 2015). Indigenous knowledges emphasize that this awareness is both phenomenologically and culturally constructed (i.e., land-based activities and stories) and helps us understand that humans are subject to the same principles of interconnectedness and adaptation (Salmón, 2000; Nabigon and Wenger-Nabigon, 2012).

My students' testimonies of personal growth and mental wellness in response to the intervention are collectively represented by *trait resilience*—the cognitive and emotional flexibility that allow us to adapt to changing situations (Hinton and Kirmayer, 2017). With a conceptual narrative of complexity priming nature-immersions, when my students witnessed, related to and connected to nature over time, their self-discovery was more likely to take on resiliency traits of adaptive systems. Students felt they internalized traits of nature and learned from its behavior. By viewing the environment as a dynamic and permeable space we are all part of, they felt less lonely, discovered that we cannot control the world, and yet also realized their interactions with the environment are impactful and meaningful.

Attachment to place is influenced by individual and group identities that form our understanding of that place and the culturally meaningful activities we do there (Low, 1992; Bonaiuto et al., 2019). In turn, the culturally meaningful symbols of place are internalized as they shape our thought patterns and identity. Thus, setting activities and conceptual theory can be structured to empower students with a dynamic, adaptable, and process-oriented concept of nature that is both externally and internally applied.

Another outcome of a self-construct embedded in nature is the long held Indigenous understanding that the wellbeing of humans and nature are synonymous, and an associated environmental concern (Adelson, 2000; Nabigon and Wenger-Nabigon, 2012). My students became more aware of how we internalize the environment physically, psychologically, and, for some, spiritually. Other research shows that people tend to go to their favorite settings for restoration and emotional self-regulation—which are most often natural settings with beautiful scenery, complexity, and richness—over time, these settings form part of their identity (Korpela and Hartig, 1996; Korpela et al., 2020; Folmer et al., 2013). With the concept an interactive environment, my students were empowered with a conscious ability to self-regulate their emotions by changing their settings as well as their focus of attention. They took comfort in knowing they have this capacity.

Thus far, we see how conceptual and perceptual experiences of the intervention provided students with a greater *sense of coherence*, where internal and external stimuli are understandable, manageable, and meaningful (Antonovsky, 1996; Eriksson and Mittelmark, 2017). As a result, students were motivated to be agents in the environmental movement as well as their own internal being.

Outdoor adventure recreation for university students involves autonomous learning through physical and mental challenges that not only enhance mental wellbeing and nature connectedness (Kanters et al., 2002) but also sustainability mindsets of agency, resilience, and willingness to take risks (Takayama et al., 2018; Davidson and Ewert, 2020). While the intervention did not involve physical challenges, it provided ample other opportunities for agency-building through autonomous learning and problem solving. Students chose their field sites and assignment topics and learned at their own pace in their own time. With each visit they discovered new input, directed neither by their own habitual patterns of thought nor prefabricated information being fed through a computer screen, but through exploration, creativity and watching life unfold.

Autonomy in how and what they learn gave students a sense of freedom absent from online learning. In another case of integrated outdoor learning, Grimwood et al. (2018) found that curiosity, intrinsic motivation, and sense of autonomy are inspired by providing more questions than answers and directing attention toward patterns in the environment rather than labeling components of the environment. They used a range of techniques like ceremonial routines, arts, introspection, wandering, challenges, and exploration.

Along with freedom, student experiences in my course were also imbued with security, stability, and non-randomness. With the assumption that social, physical, and work life are resource depleting, we see an abundance of studies measuring psychological restoration during passive experiences like walking, sitting, or meditating in unfamiliar natural settings. The intervention provided more structure and depth of connection to setting than passive mind wandering.

Scientific inquiry and applications directed attention to new patterns, detail and relationships in the same setting that progressively gained value and meaning over time. Students learned to pay attention and stay present with their senses, but were eventually motivated by their own curiosity and effortless fascination.

Williams et al.' (2018) theory of creative thinking during psychological restoration in nature proposes that internally oriented "mind wandering," which offers flexible thought, is alternated with externally oriented soft fascination with environmental stimuli, which grounds these thoughts with structure. Consistent with this, attention during undirected observations of my intervention was described as free and wandering, yet bonded to nature. However, this took place after weeks of learning to pay attention and connecting to nature.

Most ART studies to-date measure directed attention capacity after undirected nature experiences. Research in nature-based mindfulness demonstrates that semi-directed attention to nature itself seems to enhance effortlessness and restorative benefits and, further, that awareness of the present can be learned by directing attention to nature. The initial stages of learning mindfulness meditation are effortful and actually deplete cognitive resources. Yet this effort is reduced when the practice is directed at natural scenery, and thus seems to be moderated by interest, pleasure, and curiosity (Lymeus et al., 2017). Directed attention toward specific elements of nature (e.g., leaf color, smell of air) can not only enhance mindfulness during a walking mediation, it can enhance mood and nature connectedness (Nisbet et al., 2019). Mindfulness practices are a form of attending to the present moment by drawing attention and awareness to sensory experiences (Hinton and Kirmayer, 2017). As expressed by my students, this can reduce ruminative and self-critical thought patterns.

Thus far, restoration research on directed attention to elements of nature does not consider their sociocultural meaningfulness, reflecting another underlying assumption of Kaplan and Ulrich that is overemphasized: restoration is mediated by fascination with nature's beauty. When nature is removed from our purposeful daily routines, we become spectators who only see its beauty, leading to very different outcomes in our human position and possibilities. Recall the student who initially saw the environment "aesthetically." With directed prompts and scientific understanding, they began paying attention to "patterns, clusters and arrangements" and saw the environment as increasingly interactive, complex and part of our living community.

The overall course narrative facilitated understanding of nature observations and provided meaningful vocabulary that

supported both theory comprehension and a shared language for communicating these experiences in a social community. As stated by Sato and Conner (2013), the *how* of paying attention to nature matters, and we can actively cultivate our fascination and wonder in nature. This is significant to sustainability pedagogies in world no longer directly dependent on navigating natural patterns or associating these symbols shared cultural meaning.

Over the term, the students seemed to experience a cycle of security, stimulation, curiosity, and connection with nature. I want to emphasize that setting continuity and purpose-directed attention appear to be key factors in the level of familiarity and curiosity in this cycle. Attention that would otherwise by occupied by a high degree of novelty was directed at discovering finer details previously unnoticed. Unlike lockdown restrictions, novelty in their nature settings involved subtle changes that were relatively easy to integrate with nature conceptions and course narratives. Thus, the ability to witness recurring patterns in both nature and sensory experiences revealed a permeance in natural laws that students could be certain about, yet a dynamism that kept them wondering. This was aptly summarized as: "the complexity and perpetuity of nature's cycles inspired me as much as it calmed me."

Students made numerous statements like this, which I believe reflect Kaplan's Preference Matrix based on understanding and exploring the environment. For example, they were able to draw upon familiar, reliable orientation points in their setting to help them measure novel interactions of a dynamic living system. Further, the course sparked a sense of wonder and curiosity that drove a desire to understand the meaning of these interactions. While the Matrix describes why certain settings are preferred, the present work demonstrates how we can encourage understanding and exploration with setting recursiveness and purposeful inquiry. Students did not move to a preferred setting, rather their *perception* of the setting itself had shifted.

Students initially experienced anxieties, disinterest, and tediousness in a mundane setting, traits they also used to describe the lockdown experience (monotonous/unpredictable). Their newfound love of nature as comforting and engaging was accompanied by a new sense of self. Others have found that personal growth in the form of self-discovery and self-efficacy in outdoor learning initially involves a challenging period of discomfort and negative emotions, followed by a period of transformation as one overcomes these challenges (Quay et al., 2002; Taniguchi, 2004). Not only are they left satisfied with a sense of accomplishment, the new self holds greater trait resilience and capacity to undergo more growth in the face of new challenges (Hinton and Kirmayer, 2017). As alluded to by my students, the ability to process this cognitive and identity restructuring is supported by reflective writing and collective discussion (Taniguchi, 2004). We see something similar in awe experiences inspired by beauty, novelty, and complexity of natural phenomena. Keltner and Haidt (2003) propose awe starts with wonder and is followed by discomfort as cognitive structures adjust to making sense of the novelty. If this newness is well integrated into meaningfulness, it can end in profound personal growth. In sum, novelty stimulates growth and resilience when it is well integrated into a stable state.

Knowledge integration and reflection in my class were facilitated by unrestricted nature visits, field book observations, personal journaling, and class discussions, all culminating in the Reflection Assignment. Periods of introspection were associated with greater self-awareness and sensory awareness. The opportunity to look back at their field book entries with the Reflection Assignment made students aware of how their cognitive and emotional states changed over time—and in response to different conditions—and to further integrate observed novelties into a coherent narrative. Importantly, the common discourse and shared sense of purpose realized during class discussions provided social connection in lonely time.

Straker (2014) offered a similar multi-dimensional approach, observing that outdoor educators inspired meaningful engagement and respectful relationships by encouraging pro-environmental values in applied settings, opportunities for overcoming challenges, spontaneous learning, and quiet introspection. Sharing outdoor discoveries among a social community has shown to strengthen connection to nature (Grimwood et al., 2018). Journaling, gratitude practices, and meditation in a nature expedition supported both social and ecological care, referred to by Nielsen (2016:9) as an "ecology of giving." During an introductory environmental studies class, weekly multimedia nature journals (i.e., Blogs) increased nature awareness and outdoor interest, without outdoor exposure (Arnold, 2012). Like my students' testimonies, these outcomes were mediated by greater awareness of seasonal changes and understanding the social context of the nature setting (the neighborhood).

Narratives of nature-immersion pedagogies have an important role in scientific comprehension, agency, and sustainability applications, as demonstrated by my students' testimonies and assignment applications. Simple inclusion of natural elements in a university classroom improves knowledge retention (Holden and Mercer, 2014). Science classes situated in applied outdoor settings has been associated with a sense of accomplishment—in the case of nature restoration (Ernst et al., 2006), better performance in science, reading and writing—when studying a wetland (Santelmann et al., 2011), and greater intrinsic motivation, competence, and autonomy—in the case of outdoor adventure (Mackenzie et al., 2018). In all these studies, science was made more interesting and enjoyable.

Kuo et al. (2019) propose that academic performance in nature-immersion pedagogies is moderated by greater interest, stress reduction, cooperation, and sense of security in a "calmer" context, as well as the tendency to offer more autonomous learning in these settings. Almost all of these attributes were presented by my students as moderators (no opportunities for social cooperation in nature). As stated above, scientific knowledge played a major role in engaging student interest and intimacy with their space and shaping interpretations of sensory experiences.

The personal and academic outcomes—notably, sense of coherence, complexity, and agency—also demonstrate the importance of delivering environmental science in a way that does not solely direct attention to discrete and separable details, but also to relationships in a dynamic living setting. Processing scientific discovery in a social setting and applying it to broader social realities seems to improve student interest and influence sustainability mindsets.

Conclusion

This nature-immersion intervention during a pandemic lockdown provided a consistent learning space that meaningfully engaged student minds and bodies and improved self-reported mental wellness. By the end of the term, students perceived their internal states and nature itself with a greater sense of security and stimulation. They demonstrated sustainability mindsets and wellbeing outcomes that are relevant beyond lockdown scenarios. This pedagogy of freedom and structure empowered sense of coherence, awareness, and agency through ongoing dialog between theory and immersive experience.

This work suggests that directed attention to nature is increasingly effortless when intrinsically motivated by a cultural narrative of meaningful relationships that asks us to derive and apply information drawn from nature. A cycle of meaningfulness, effortlessness, connectedness (nature and social), curiosity, discovery, and restorativeness may be enhanced by recurring visits to the same setting over time, mixed with periods of collective and introspective integration.

By directing attention in this manner, nature-immersion inquiry is an engaging and accessible pedagogical tool that can be used in simple settings (e.g., tree) with many different learning styles that can teach students how to pay attention. We also have the opportunity to be conscious of the underlying constructs of nature we present—a beautiful escape or a meaningful teacher and community—influencing student capacity to see adaptive complexity in sustainability systems and themselves.

This paper challenges the notion that daily routines and real scientific rigor are necessarily resource depleting and apart from affective sensory experiences in nature. We need not assume punitive styles of higher education that require restoration; we can harmonize internal and external meaningfulness to engage and inspire the whole person.

Limitations and future research

The degree and direction of study outcomes were not measured. However, isolating linear causal effects may not be useful to interdisciplinary, integrated pedagogies. The outcomes were analyzed from a student assignment, which risks influence from impressions of professor expectations. Students documented observations and insights over the term and communicated them without any knowledge of my strategies and working theory. Student perception is the focus of this inquiry, which has provided plenty of insight for pedagogical applications and future research. Notably, the results compel empirical investigation on contexts driving purpose-directed attention, and the outcomes on fascination, attention effort and restoration.

Data availability statement

The datasets presented in this article are not readily available. Requests to access the datasets should be directed to nicole.spiegelaar@utoronto.ca.

Ethics statement

The studies involving human participants were reviewed and approved by The University of Toronto's (U of T) Human Research Ethics Unit (HREU). The patients/participants provided their written informed consent to participate in this study.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Factors influencing the financing behavior of large professional households engaged in green agricultural production in China

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Green agriculture is the direction of sustainable development of China's modern agriculture and the inherent requirement of taking the road of characteristic new agricultural modernization. As one of the main bodies of new agricultural management, professional large households are of great significance to lead the development of efficient agriculture and accelerate the development of green agricultural economy in Heilongjiang. Therefore, based on the theory of planned behavior, this article includes 275 major professional households in Heilongjiang Province as a sample of demonstration counties (cities) for green, high-quality, and efficient creation, combined with field research data and structural equation model, and discusses the willingness of large professional households to participate in green agricultural production financing and behavioral factors and mechanisms of action. The perceived behavior control (PBC), attitude toward the behavior (AB), and subjective norms (SNs) of large professional households to engage in green agricultural production determine their financing intentions (FNs), which further determines their financing behavior (FB). The results show that PBC, AB, and SN have a significant positive impact on the FN of large professional households, and further indirectly affect the FB. It should be noted that SNs have the most significant impact on the FN of large professional households to participate in green agricultural production. Therefore, it is necessary to establish effective government propaganda measures and preferential policies, improve the awareness of the importance of green agricultural production financing, and create a good social atmosphere for agricultural sustainable development and active participation in financing. The purpose of this study is to provide a reference for policymakers to formulate relevant policies to cultivate major professional households and develop green agricultural economy in Heilongjiang Province.

KEYWORDS

large professional households, green agricultural, theory of planned behavior, financing behavior, influence factor

1. Introduction

Green agriculture is an inevitable requirement of China's agricultural economic development. China's agricultural development has made great achievements; however, the long-term extensive mode of production and the neglect of the ecological environment lead to the increasingly prominent contradiction between agricultural production and the ecological environment. The soil conditions of agricultural production are superior. Heilongjiang Province is the largest plain in China's black land and one of the three black land regional plains in the world. The soil's organic matter is very rich. The output of green agriculture in Heilongjiang Province ranks first in China and is an important base for food security in China.

As an important agricultural base in China, although Heilongjiang has certain resource advantages, it also faces the dual pressure of resource conditions and ecological environment in recent years. Modern agriculture has higher productivity than traditional agriculture, but it poses a threat to resources and the environment. Therefore, the development of green agricultural production is consistent with the goal of ecological agriculture, which plays a role in protecting the environment of producing areas and ensuring the sustainable development of agriculture (Ali et al., 2015). The development of green agriculture is based on ecological agriculture, which is a scientific and green development concept (Carneiro et al., 2017). Koohafkan (2012) believes that the development of green agricultural production can scientifically and effectively adjust the allocation structure of agricultural production factors, ensure the safe supply of agricultural products, and optimize the ecological environment. Therefore, the development of green agricultural production is of great significance for the industrialization and sustainable development of green agriculture in Heilongjiang Province.

The development of green agriculture emphasizes the conservation and efficient utilization of resources. It needs sufficient funds to improve the traditional production mode through technological innovation. Driven by the marketization of the rural economy and the diversification of farmers' operation, farmers' demand for funds is increasing (Sijtsma and Molenaar, 2002). However, the lack of funds has become the most important obstacle to the development of green agricultural production. Green agricultural production integrates all links before, during, and after production, and promotes the integration of business mode, socialization of service, and enterprise management (Hattam and Holloway, 2005). Due to the lack of funds for most farmers, farmers continue to use traditional production methods in agricultural production, which affects the enthusiasm of farmers to participate in green agricultural production (Ingram, 2010). It is undeniable that farmers have sufficient funds for green agricultural production, which is the premise of green agricultural development. Therefore, the development of green agriculture requires a lot of financial support from the government.

With the rigid growth in domestic demand for agricultural products and the continuous improvement in quality and safety requirements, the agricultural production mode characterized by small farmers' intensive cultivation is challenged, and it is crucial to speed up the cultivation of new agricultural operators (Banjongrewadee et al., 2020). In recent years, new agricultural entities such as professional large households, family farms, and farmers' cooperatives can organize scattered farmers to carry out green agricultural production, develop innovative green agricultural production mode, ensure the quality and safety of agricultural products, and promote the development of regional green agricultural industrialization (Durak and Saritepeci, 2017). As one of the main bodies of new agricultural management, with the continuous increase in land scale and policy support in China, the number of professional large households has increased greatly and has provided an important force for green agricultural production. Large professional households have moderate-scale and specialized production characteristics and have a good sense of modern operation and management (Lohr and Salomonsson, 2000). However, from the perspective of personal characteristics, due to the influence of age, education level, risk preference, and environmental protection concept, large professional households have a certain cognitive bias to engage in green agricultural production and financing. This will further affect the scale and quality of green agricultural production (Yuelai et al., 2020). Therefore, the willingness and behavior of green agricultural production financing of large professional households is the key to realizing green professional and sustainable development of agriculture in China.

At present, the above research mainly includes the following aspects. First, it is about the research on green agriculture. In the book *Green Knowledge Shaping: Environmental Politics and Cultural Evolution*, Kniss et al. (2016) provided his fellow environmentalists with a "progressive report" on the sustainable development of human society. In *Spirit of Green Transformation*, Aroca et al. (2007) viewed the contribution of environmentalists to environmental protection and the role of green concept communication from a historical perspective. Adhikari et al. (2017) cited diffusion theory to explain the influence factors of green production adoption rate change. Milroy et al. (2013) showed that the production of green, high-quality, and safe agricultural products has been highly valued by governments and welcomed by consumers, which stimulates the green development of agriculture. Orenstein et al. (1976) defined the green development of agriculture as taking the safe production of agricultural products as

the goal and emphasized that science can effectively adjust the allocation structure of agricultural production factors, so as to ensure the safe supply of agricultural products while optimizing the ecological environment at the same time. Pingali (2012) studied the influencing factors of agricultural green development. Lapple and Donnellan (2009) believed that the green development of agriculture is an exploration of the process of sustainable development of agriculture based on respect for nature, the guarantee of green development system construction and mechanism innovation, and the support of modern technology. Second is the research on the demand of funds for green agriculture. Frantál and Prousek (2016) emphasized that the importance of developing green agriculture is increasingly apparent because the development of agriculture needs enormous financial support; therefore, how to solve the problem of insufficient funds is particularly critical. Liu et al. (2020) proposed to use of green science and technology to produce green agricultural products and play a key role in financing. Pan et al. (2017) found that through the intervention measures of subsidies, taxation, public R&D, and international assistance, the green employment plan of environmental protection and recovery is formulated to promote the green development of agriculture. Raza et al. (2019) proposed to focus on the ecological compensation mechanism of agricultural green production and put forward the implementation strategy of green development policy financial support according to the actual situation of national development. Third, it is about the research on the financing behavior (FB) of farmers. Roos and Hahn (2016) used the Heckman two-stage model to analyze the main factors affecting the sample farmers' lending behavior and credit constraints. Struik and Kuyper (2017) found that there is a linear relationship between the farmers' own factors such as farm area, knowledge, and cultural level, and the proportion of financing they can obtain from financial institutions. Whittinghill and Rowe (2012) showed that the most important factors affecting the attitude of green farmers are health and environmental awareness. Evermann and Tate (2016) used a structural equation model to analyze the impact of age, education, and experience on farmers' willingness to adopt organic production. Zhong (2011) used the Probit model to investigate the effects of farm characteristics, cost–benefit, and market information on organic farmers' willingness to produce. Montoro et al. (2018) found that agricultural credit is of great significance for the development of agricultural modernization, improving farmers' participation in the production process, and then improving production efficiency (Ponnapureddy et al., 2020). In particular, for farmers who use financing to purchase agricultural machinery and equipment, agricultural credit can also improve their net income. In the study, it is proposed that each characteristic of farmers' economic behavior is a rational choice made by internal constraints and external environment stimulation.

The academia has formed a wealth of research results in the field of green agriculture and farmers' FB, which has laid a solid foundation for this article to carry out the research on the financial behavior of large professional households in green agriculture, but there are still shortcomings. First, scholars are more from the traditional agricultural level to study farmers' FB, and the research on green agriculture level needs to be supplemented. Second, the main body of the study is mainly concentrated on ordinary small farmers (Demiryurek and Ceyhan, 2008), ignoring the important impact of FB on professional large farmers as a new agricultural management body on the sustainable development of green agriculture. Third, the research on farmers' financial behavior only stays at the national level while lacking research on farmers' FB in provinces, especially in Heilongjiang. Fourth, the research methods lack innovation.

Based on this, the innovation of this article is mainly reflected in the following aspects. First, from the perspective of green agriculture, the FB of farmers from the level of green agricultural production is studied in this article. Second, the main body of the study is the new agricultural management subject (major professional households), and it explores the factors influencing the FB of the major households and the important role of FB in the development of green agricultural production. Third, taking Heilongjiang as the research object makes up for the defects of the past research on the FB of the farmers. Fourth, based on the theory of planning behavior, this article analyzes the influencing factors of professional large-scale FB, discusses the degree of influence of the various factors on FB by building a structural equation model, and provides innovative research methods for the study of green agriculture and FB of professional large-scale households.

2. Theoretical analysis framework and research hypothesis

2.1. Theoretical analysis framework

The theory of planned behavior (TPB) shows that people's behavior is the result of careful consideration, and all the factors that may affect behavior are indirectly affected by behavior intention. For large professional households to participate in green agricultural production research, the logical relationship among the three is expressed as "financing cognition→ financing intention→ financing behavior." In the TPB, the financing intention (FN) of large professional households to green agriculture mainly depends on three factors: Perceived behavior control (PBC), attitude toward the behavior (AB), and subjective norms (SNs). Therefore, this article analyzes the FN and FB of large professional households to participate in green agricultural production from the three aspects of PBC, AB, and SN. The theoretical framework is shown in **Figure 1**.

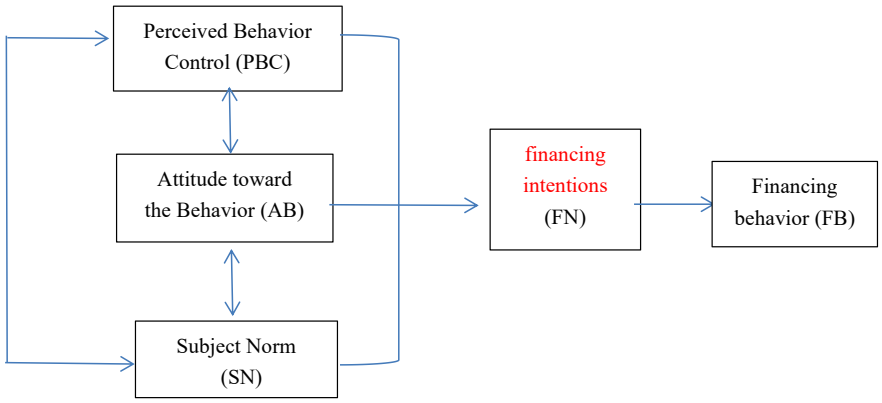

FIGURE 1
Theoretical analysis framework.

2.2. Research hypothesis

According to the perceived behavior control theory, when an individual thinks he or she has more resources and opportunities, he or she will expect fewer obstacles, thus the perceptual behavior control over his or her behavior will be stronger. The PBC of large professional financing can be understood as the control ability of large professional financing for green agricultural products according to their past experience and expected obstacles. Self-efficacy refers to an individual's speculation and judgment on whether he or she has the ability to complete a certain behavior. If a large professional household has confidence in his or her financing ability, he or she will have higher self-efficacy and a positive attitude toward FB. On the contrary, he or she will have a negative attitude. If large professional households have high control and can deal with the uncertainty of green production financing according to the resources and expectations they have, they will have stronger PBC. Therefore, this article measures the PBC of large professional households on green agricultural production financing from four aspects, namely, the understanding of green agriculture and green agricultural products, the awareness of agricultural product safety and ecological protection, the ability to participate in green agricultural production financing, and the positive impact of participation in financing on green agricultural production. Based on this, hypothesis H1 is proposed.

> H1: The strong PBC of large professional households has a positive impact on their FI of green agricultural production.

Attitude is formed by an individual's evaluation of a specific behavior after conceptualization. Therefore, the composition of attitude is often regarded as a function of an individual's significant belief in the outcome of the behavior. According to the cost–benefit theory, from an economic point of view, the expectation that benefits are greater than costs is the basic starting point of people's behavior. For large professional households that specialize in agricultural crop planting, whether the economic utility brought about by participating in green production financing can meet the expectations is the primary principle that affects their FB and attitude, and also reflects the cognition of the consequences of FB. The subjective perception of the social and economic effects of green agricultural production and the conceptual cognition of FB are also important factors affecting their financing attitudes and behaviors. Risk preference refers to the basic attitude of individuals to take risks and is an important leading factor for individuals to perceive decision-making situations and make risk decisions. The risk attitude of large professional households toward financing green agricultural production affects their financing decisions and attitudes. The higher the risk tolerance, the greater the willingness of FB. Therefore, this article evaluates the behavior and attitude of large professional households to participate in the financing of green agricultural production from four aspects, namely, the psychological expectation of the economic effect brought by participating in the financing of green agricultural production, the cognition of the importance of ecological protection and sustainable development, the cognition of the importance of financing green agricultural production, and the risk attitude of the FB. Based on this, hypothesis H2 is proposed.

> H2: The positive behavior and attitude of large professional households have a positive impact on their willingness to finance green agricultural production.

Subjective norms can be said to be the pressure that an individual and important others or groups think that whether they should take a certain behavior. The mandatory norms of

TABLE 1 Investigation of sample essential information.

Index	Category	Frequency	Rate of recurrence
Gender	Male	254	92.4%
	Female	21	7.6%
Age	Under 50	45	17.7%
	50–55 years old	14	5.5%
	55–60 years old	108	42.5%
	Over 60 years old	87	34.3%
Education level	Junior high school and below	75	27.3%
	High school	99	36%
	Junior college	86	31.3%
	Undergraduate	12	4.3%
	Master degree and above	3	1.1%
Family population	<3	20	7.3%
	3–5	157	57.1%
	5–7	63	22.9%
	>7	35	12.7%
Annual labor consumption	<3	12	4.4%
	3–5	121	44%
	5–8	86	31.3%
	>8	56	20.3%
Cultivated land area	<100 mu	31	11.3%
	100–150 mu	121	44%
	150–200 mu	89	32.4%
	>200 mu	34	12.3%
Financing amount	<10 thousand	121	44%
	10–20 thousand	75	27.3%
	20–30 thousand	46	16.7%
	>30 thousand	33	12%

large professional households on green agricultural production FB mainly come from the government while the demonstrative norms mainly come from family members, neighbors, friends, social organizations, etc. The SN of large professional households refers to the social pressure they feel when they decide whether to finance green agricultural production. Green agriculture is obviously of great significance to the sustainable development of China's ecological environment. The promotion and publicity of green agriculture by the government can further meet the needs of agricultural producers and create greater economic benefits for farmers. The government provides corresponding subsidies, concessions, and exemptions for farmers to produce green agricultural products, which can not only effectively alleviate the pressure of agricultural financing but also form a normative concept from the perspective of social pressure. The green production concept and environmental protection awareness of the surrounding people further affect the willingness and behavior of large professional households for green agricultural production financing. SN and individual behavior intention usually show a significant positive correlation. The stronger the SN is, the stronger the FI of large professional households will be; the weaker the SN is, the weaker the FB will be. Therefore, the government's promotion and publicity of green agriculture, the government's preferential policies and financial subsidies, and the social atmosphere of ecological security and resource protection are used to measure the subjective normative cognition of large professional households on green production FB. Based on this, hypothesis H3 is proposed.

> H3: The SNs of large professional households have a positive impact on their willingness to finance green agricultural production.

3. Materials and research methods

3.1. Data sources

Heilongjiang Province, with a green, high-quality, and high-efficiency creation demonstration county project, is an important green agriculture development base in China. In Heilongjiang Province, for example, the project of establishing green, high-quality, and high-efficiency demonstration county for rice in Jixi and Hulin is foliar fertilizer; Wudalianchi has become a national commodity grain base county, a basic farmland protection demonstration area, a national green, high-quality, and efficient demonstration county, and a national regional soybean breeding base, with an area of 1.5 million mu certified for green organic agricultural products. Baoqing County, in Shuangyashan City, declared and implemented the national green, high-quality, and efficient rice production base project. Therefore, this questionnaire conducted a field survey in 6 counties (cities) and 31 villages of 18 towns in Heilongjiang. The survey samples were determined by a stratified sampling method. The survey method mainly adopted face-to-face interviews between investigators and the major labor force of major professional households. A random sampling method was used for the questionnaire survey. A total of 287 questionnaires were issued, and 275 valid questionnaires were obtained, with an effective rate of 95.82%. The questionnaire mainly included personal information, such as gender, age, education level, family population, annual labor consumption, cultivated land area, and financing amount.

As shown in **Table 1**, among the 275 large professional households surveyed in this article, the number of households headed by men was 233, which exceeded the number of households headed by women. It can be seen that the surveyed large professional households are still dominated by males. From the perspective of family age, the largest population is 55–60 years old, followed by farmers who are >60 years old, and the lowest proportion of farmers is 50–55 years old. Being aged >55 years, they have the characteristics of aging, and the large aging professional households will further affect their financing willingness due to the characteristics of old thinking and risk aversion. The vast majority of farmers in the survey sample have an education level of junior high school or below, while the proportion of high school or above is very low, which indicates that the major professional households have a low level of education, and their business philosophy and financing awareness are poor. The household population accounts for the largest proportion of 3–5 people, and the annual operation consumes the labor force of at least 2–5 people. Large professional households need to meet the moderate-scale operation, and the annual operation of professional products needs to consume more than two laborers (usually hired workers). According to the survey on the area of cultivated land operated by large professional households, most farmers have an area of 100–150 mu of cultivated land, followed by 150–200 mu of cultivated land, and the proportion of cultivated land <100 mu is the lowest. In other words, the 275 large-scale professional households surveyed have a relatively large scale of cultivated land, which generally meets the requirements of large-scale professional households operating arable land of >100 mu, therefore, it is more likely for an individual to get a financing loan. According to the survey of the financing amount of large professional households, we found that the largest proportion of financing amount is <10,000:121 yuan, followed by 75 people with a financing amount of 10,000–20,000:75 yuan, and only 33 people with a financing scale of >30,000:33 yuan. This shows that professional large households are now less aware of financing, the amount of financing is small, and the conservative management method is still the choice of most large professional households.

3.2. Variable selection

Based on the setting of theoretical framework, referring to the selection of relevant variables and the results of table design in the existing research, combined with field research, this article designs a total of 17 topics according to the TPB to measure the five potential variables of large professional households on green agricultural production: PBC, AB, SN, FI, and FB. The questionnaire used Likert's five-point scale. Scores of 1–5 represent complete disagreement, disagreement, general, basic agreement, and complete agreement, respectively (Conroy and Harpe, 2015). The meaning and assignment of variables are shown in **Table 2**.

3.3. Research method

As an effective multivariate analysis method, structural equation modeling (SEM) has been widely used in many fields. The biggest advantage of SEM over the traditional econometric regression method is that it can deal with multiple dependent variables at the same time, allowing independent variables and dependent variables to contain measurement errors. The model can simultaneously analyze the influence of the relationship and path between the observed variables and potential variables. The specific forms of SEM constructed in this article are as follows.

Measurement equation:

$$\begin{aligned} X_{1i} &= \beta_j X_1 + e_j (i = 1, 2, 3, 4;\ j = 1, 2, 3, 4) \\ X_{2i} &= \beta_j X_2 + e_j (i = 1, 2, 3;\ j = 5, 6, 7) \\ X_{3i} &= \beta_j X_3 + e_j (i = 1, 2, 3, 4;\ j = 8, 9, 10, 11) \\ Y_{1i} &= \beta_j Y_1 + e_j (i = 1, 2, 3;\ j = 12, 13, 14) \\ Y_{2i} &= \beta_j Y_2 + e_j (i = 1, 2, 3;\ j = 15, 16, 17) \end{aligned} \quad (1)$$

where X_{1i}, X_{2i}, X_{3i}, Y_{1i}, Y_{2i} represent the observable variable. $\beta_j (j = 1, 2.....17)$ is the load factor of the observable

TABLE 2 Variables description and assignment.

Latent variable number	Latent variable	Observable variable
Q1	Attitude of behavior (AB)	The psychological expectation of the economic effect brought by participating in green production financing (AB1)
		Recognition of the importance of ecological protection and sustainable development (AB2)
		Recognition of the importance of green agricultural production financing (AB3)
		Risk attitude toward financing behavior (AB4)
Q2	Subject norm (SN)	Government's promotion and publicity of green agriculture (SN1)
		Government's preferential policies and financial subsidies (SN2)
		Social atmosphere of ecological security and resource protection (SN3)
Q3	Perceived behavioral control (PBC)	Understanding of green agriculture and green agricultural products (PBC1)
		Safety of agricultural products and awareness of ecological protection (PBC2)
		Ability to participate in green agricultural production financing (PBC3)
		Participation in financing has a positive impact on green agricultural production (PBC4)
Q4	Financing intentions (FN)	The degree of willingness to participate in green agricultural production financing (FN1)
		Willing to actively understand financing methods and financing conditions (FN2)
		Willing to help the government publicize and promote green agricultural products financing (FN3)
Q5	Financial behavior(FB)	Willing to finance under certain risk (FB1)
		Willing to improve green agricultural production technology through financing (FB2)
		Willing to achieve sustainable development of resources through financing (FB3)

Here, for convenience, we used Q1 to represent attitude of behavior, Q2 to represent subject norm, Q3 to represent perceived behavioral control, Q4 to represent financing intentions, and Q5 to represent financial behavior.

variable. $e_j(j = 1, 2.....17)$ represents the residual of each regression equation.

Structural equation:

$$\begin{aligned} X_2 &= \alpha_1 X_1 + \mu_1 \\ X_3 &= \alpha_2 X_1 + \mu_2 \\ Y_1 &= \alpha_3 X_1 + \alpha_4 X_2 + \alpha_5 X_3 + \mu_3 \\ Y_2 &= \alpha_6 X_1 + \alpha_7 X_2 + \alpha_8 X_3 + \mu_4 \end{aligned} \tag{2}$$

where X_1, X_2, X_3, Y_1, Y_2 represent the latent variable. α_1, $\alpha_2 \ldots\ldots \alpha_8$ represents the path coefficient between latent variables. $\mu_1, \mu_2, \mu_3, \mu_4$ represents the residual between latent variables.

4. Results and analysis

4.1. Reliability analysis

The reliability test refers to the reliability of the questionnaire. It refers to the repeated measurement of the same object by the same method. The credibility of the questionnaire is also the reliability of the questionnaire, which refers to the consistency of the results obtained when the same method is used to repeatedly measure the same object, that is, the degree of reflecting the actual situation. The most commonly used measurement index is Cronbach's alpha coefficient. It is generally considered that 0.60–0.65 is unacceptable, 0.65–0.70 is the minimum acceptable value, 0.70–0.80 is better, and 0.80–0.90 is very good (**Table 3**). Cronbach's alpha of the questionnaire is 0.900, which belongs to high reliability. The overall Cronbach's alpha coefficients of AB, SN, PBC, FI, and FB are 0.902, 0.888, 0.914, 0.946, and 0.871, respectively. The consistency and stability of the questionnaire are very good.

4.2. Validity test

Validity analysis, simply speaking, is the validity and accuracy of the questionnaire design, which is used to measure whether the item design is reasonable. Validity can be divided into validity, construct validity, and criterion validity. Construct validity refers to the corresponding relationship between measurement items and measurement dimensions. There are two measurement methods, namely, exploratory factor analysis and confirmatory factor analysis. An exploratory factor analysis is the most widely used method to measure construct validity. In order to further measure whether the overall structure of the questionnaire is reasonable or not,

exploratory factor analysis is carried out on latent variables. The exploratory factor analysis is a technique used to find out the essential structure of multivariate observation variables and reduce the dimension. First, this article tests the consistency of variables. By using SPSS 24.0 and the principal component extraction method, it uses the maximum variance rotation method to analyze the data. The results showed that the value of Kaiser–Meyer–Olkin (KMO) was 0.835 (as shown in Table 4), the Bartlett spherical test value was 0.000, and the test results were significant. These data were suitable for factor analysis. After the orthogonal rotation, the observed variables were aggregated into five components; this is the same as the original components and consistent with the theoretical model. The total cumulative variance of the five common factors is 82.207% (as shown in Table 5), indicating that the potential scalar design is reasonable and the scale has good structural validity. It is generally assumed that the value of factor load >0.5 indicates a higher convergence of the scale (Table 6). Among the factors to which the questionnaire belongs, the more the factor load value of measurement variables is >0.5, the higher the discriminant validity between the factors. After calculation, the factor load values of 17 of the five potential variables were >0.5, indicating that the questionnaire has good convergence validity and discriminant validity. AB, PBC, SN, FI, and FB have good explanatory power.

TABLE 3 Reliability statistics.

Project	Cronbach' alpha	Number of items
All measured variables	0.900	17
Behavioral attitude measurement variables	0.902	4
Subjective norm measurement variables	0.888	3
Perceptual behavioral control measurement variables	0.914	4
Measurement variables of financing intentions	0.946	3
Measurement variables of financing behavior	0.871	3

TABLE 4 Kaiser–Meyer–Olkin and Bartlett test results.

Kaiser-Meyer-Olkin		0.835
Bartlett sphericity test	Approximate chi-square	2610.705
	Freedom	361
	Significance	0.000

4.3. Model fitness analysis

One of the hypotheses of the SEM model is that the expected covariance matrix minus the sample covariance matrix is 0. According to this hypothesis, the fitness index is proposed and divided into two categories: One is to check whether the similarity of the two models is the highest (the highest value is 1, >0.8 is acceptable, >0.9 is good), the other is to check whether the dissimilarity of the two models is the minimum (the minimum is 0, ≤0.8 is acceptable, <0.5 is good). The first type is the benign fitness index (GFI), the comparative fitness index (CFI), the regulatory fitness index (NFI), the relative fitness index (RFI), and the value-added fitness index (IFI), in which GFI = 0.902, NFI = 0.923, CFI = 0.963, RFI = 0.906, and IFI = 0.963. The second type is the root-mean-square error of approximation (RMSEA) = 0.066.

As shown in Table 7, the value of the chi-square degree of freedom ratio (CMIN/DF) is 1.856, which conforms to the fitting standard (1 < CMIN/DF < 3), and indicates that the sample data have a good degree of fit with the theoretical model, and the comprehensive fitting degree is good. Because the chi-square degree of freedom of SEM is easily affected by the sample size, and the SEM fitting criterion is not unitary, the evaluation index should be objective and comprehensive. In the absolute fitting index, GFI = 0.902 > 0.9.

Root-mean-square error of approximation = 0.066 (<0.08), which indicates that the absolute fitting degree of the model is high, and the indexes are well matched. NFI = 0.923 (>0.9), CFI = 0.963 (>0.9), RFI = 0.906 (>0.9), and IFI = 0.963 (>0.9),

TABLE 5 Principal component analysis was used to extract the results.

Component	Extract the load sum of squares			Sum of squares of rotational loads		
	Total	Variance percentage	Cumulative percentage	Total	Variance percentage	Cumulative percentage
1	6.671	39.243	39.243	3.213	18.898	18.898
2	2.098	12.343	51.585	3.131	18.419	37.318
3	2.055	12.085	63.670	2.646	15.562	52.880
4	1.790	10.528	74.198	2.541	14.945	67.825
5	1.362	8.009	82.207	2.445	14.382	82.207

which are all ≥0.9, indicating that the model has good value-added fitting. In total, it can be seen that the model as a whole meets the fit standard, and the fitness degree of the structural equation is very good.

4.4. Analysis of model results

4.4.1. Mediating effect test

To further explore the influencing factors of large professional households' participation in green agricultural production FB, this article uses AMOS25.0 software to carry out the BOOTSTRAP test to explore its mediating effect. The random sample is set at 2,000, and the confidence interval is 95%. The results are shown in Table 8.

TABLE 6 Extraction factor.

	Component				
	1	2	3	4	5
AB1		0.849			
AB2		0.876			
AB3		0.848			
AB4		0.779			
SN1				0.877	
SN2				0.870	
SN3				0.859	
PBC1	0.847				
PBC2	0.847				
PBC3	0.889				
PBC4	0.834				
FN1			0.882		
FN2			0.845		
FN3			0.869		
FB1					0.870
FB2					0.883
FB3					0.858

4.4.2. Results analysis

According to the research model, after running AMOS25.0 software, the SEM and standardized path chart of large professional households on FN of green agricultural production were obtained. As shown in Figure 2, the path coefficient of each latent variable of the model is significant at 1% of the significance level, which has passed the test. It shows that the AB, PBC, and SN of large professional households have a significant impact on their FN to participate in green agricultural production (Table 9). The specific analysis is as follows:

(1) The path coefficient of PBC on the FN of large professional households for green agriculture production is 0.258, and their PBC has a significant impact on their FN, indicating that the fewer obstacles that large professional households expect based on past experience and the more resources they have, the stronger FN of large professional households will be. That is, hypothesis H1 holds: The strong PBC of large professional households has a positive impact on their FN of green agricultural production. From the perspective of each observation variable, the degree of understanding of green agriculture and green agricultural products (PBC1) contributed the most to the positive impact of PBC (the standardized coefficient was 0.887), followed by the ability to participate in green agricultural production financing (PBC3, the standardized coefficient was 0.886), then the awareness of agricultural product safety and ecological protection (PBC2, the standardized coefficient was 0.855), and, finally, the participation in financing has a positive impact on green agricultural production (PBC4, standardization coefficient is 0.782). Most of the major professional households are risk-averse. Only when they feel that the income generated by green agricultural production financing is greater than its financing cost, they can produce positive PBC. In addition, their own conditions and financing ability are also important factors. On one hand, if farmers are older and less educated, then their understanding of the

TABLE 7 Model fitting evaluation standard and evaluation index.

Index	Model fitting value	Fitting standard	Judgment result
CMIN/DF (chi-square degree of freedom ratio)	1.856	1<CMIN/DF<3	Good fitness
GFI (benign fitness index)	0.902	GFI>0.9	Good fitness
RMSEA (root-mean-square error of approximation)	0.066	RMSEA<0.08	Reasonable fitness
NFI (regulatory fitness index)	0.923	NFI>0.9	Good fitness
CFI (comparative fitness index)	0.963	CFI>0.9	Good fitness
RFI (relative fitness index)	0.906	RFI>0.9	Good fitness
IFI (value-added fitness index)	0.963	IFI>0.9	Good fitness

importance of financing green agricultural production is lower, which will affect their FN and FB. On the other hand, the long-term environment, financing atmosphere, and ecological protection awareness of large professional households need not only their own initiative to improve but also need the government to implement accurate and strong policy publicity and financing support. It also needs to strengthen the dissemination and training of financial knowledge of large professional households.

(2) The path coefficient of AB on the FN of large professional households is 0.277, which has passed the 1% significance level test, and there is a positive correlation between them, indicating that the more positive the AB of large professional households is, the stronger their FN is, that is, hypothesis H2 holds: The positive AB of large professional households has a positive impact on their FN for green agricultural production. From the perspective of each observation variable, the psychological expectation of economic utility brought by participating in green production financing (AB1) has the largest contribution to AB (the standardized coefficient is 0.902), followed by the cognition of the importance of ecological protection and sustainable development (AB2, the standardized coefficient is 0.882), then the cognition of the importance of green agricultural production financing (AB3, the standardized coefficient is 0.855), and, finally, the risk attitude toward FB (AB4, standardized coefficient is 0.703). In this article, trust is regarded as a kind of "psychological expectation" that will have an impact on the public's behavior and decision-making. This is also supported by the conclusion of our survey of 275 large professional households. On one hand, the psychological

TABLE 8 Mediating effect test results.

Route	Standardized path coefficient	Bootstrap	
		Lower	Upper
AB→FN→FB	0.177	0.072	0.347
PBC→FN→FB	0.184	0.085	0.340
SN→FN→FB	0.200	0.092	0.375

The confidence interval of "AB→FN→FB" is (0.072, 0.347), and the intermediate effect coefficient is 0.177. The confidence interval of "PBC→FN→FB" is (0.085, 0.340), and the intermediate effect coefficient is 0.184. The confidence interval of "SN→FN→FB" is (0.092, 0.375), and the intermediate effect coefficient is 0.200. Both ends of the confidence interval of the three paths are positive, excluding 0. Therefore, the FN has a significant intermediary effect on the participation of family farmers in the FB of green agricultural production.

TABLE 9 Path analysis results.

	Standardization coefficient	CR	*P*-value
FN←AB	0.320	3.872	***
FN←PBC	0.403	4.650	***
FN←SN	0.337	3.655	***
FB←FN	0.361	5.175	***

***Remarkable.

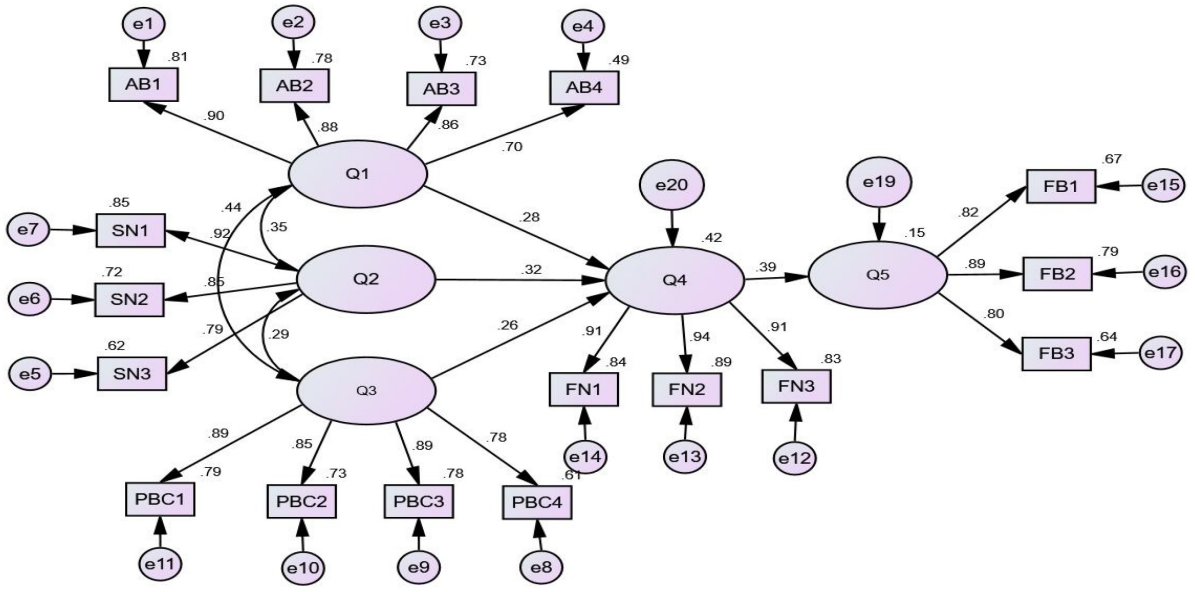

FIGURE 2
Path coefficient diagram about the influence of large professional households on FN and FB of green agricultural production.

expectation of large professional households for the economic benefits brought by their participation in green production financing comes from the cognition of their own operation and production capacity. On the other hand, it is the issue of trust in the implementation of policies by the government, that is, whether the publicity measures, compensation, and financing preferences can be effectively implemented.

(3) The path coefficient of SN on the FN of large professional households is 0.321, which has passed the 1% significance level test, and there is a positive correlation between them. SNs have the most significant impact on the FN of large professional households in green agricultural production than PBC and AB, indicating that if the large professional households face greater social pressure on whether to carry out the FB of green agricultural production, they will have a stronger FN, which means the hypothesis H3 holds: the SNs of large professional households have a positive impact on their FN for green agricultural production. From the observation variables, the government's promotion and publicity of green agriculture (SN1) have the greatest positive impact on SN (standardization coefficient is 0.921), followed by the government's preferential policies and financial subsidies (SN2, standardization coefficient is 0.849), and, finally, the social atmosphere of ecological security and resource protection (SN3, standardization coefficient is 0.787). From this, we can see that the government's mandatory norms have a greater driving effect on the FN of large professional households to participate in green agricultural production than the model norms, which also shows that their SNs to participate in green agricultural production financing are largely affected by the government's efforts to promote and publicize green agriculture, as well as the government's preferential policies and financial subsidies. It also makes large professional households show awe and obedience to the policies implemented by the government. This top-down influence on large professional households makes the government play a very good leading role.

5. Conclusion and policy implications

As an important starting point of agricultural moderate-scale operation and development of modern agriculture, large professional households are motivated to actively raise funds to promote green agriculture production, which is an inevitable choice for China to develop modern green agriculture. It is also of great significance to the security of the agricultural ecosystem, national food security, and the promotion of agricultural international market competitiveness. Based on the TPB, this article investigates 275 professional households in 6 counties (cities), 18 townships, and 31 villages of Wudalianchi City, Hulin City, Baoqing County, Ning'an City, Jixi City, and Hegang Suibin County in Heilongjiang as research samples. By directional designing, distributing, collecting, and sorting out questionnaires, based on the SEM, this article investigates the factors influencing the FB of large professional households and green agricultural production in Heilongjiang, and concludes that the AB, PBC, and SN of large professional households have a significant impact on their FN of green agricultural production, which can further affect the FB of large professional households. Therefore, the following countermeasures are put forward:

The main conclusions are as follows. (1) From the perspective of perceptual behavior control, we found that the financing willingness of large professional households is affected by past experience expectations, resources at their disposal, their understanding of green agricultural products, and their participation in green agricultural production. Financing ability is an important factor affecting financing willingness and FB. (2) From the perspective of behavioral attitudes, the psychological expectations of the economic utility brought by the participation of large professional households in green agricultural production financing greatly affect their financing willingness, which, in turn, affects their FB's. From the perspective of SNs, the social pressure felt by large professional households on whether to finance green agricultural production has the most significant impact on their willingness to finance. The following countermeasures are therefore proposed:

(1) Strengthening the construction of rural talents and improving the training system for new professional farmers is the key. At present, the large professional households in Heilongjiang Province have problems of serious aging and generally low education level. In order to improve the production and operation knowledge and concepts, financial product recognition, and scientific and cultural literacy of large professional households, the local government and educational institutions in Heilongjiang Province should focus on promoting rural areas. Build a talent training system, establish a comprehensive talent assessment and incentive mechanism, and at the same time strengthen the introduction of talents with advanced scientific research conditions and high-quality, and expand the professional and large-scale talent team.

(2) Improve the production and operation capabilities of large professional households, and strengthen the cultivation of green agricultural producers' moral culture, market

awareness, and management skills. At the same time, the government should effectively implement financial support for large professional households engaged in green agricultural production. In order to strengthen the awareness of ecological protection and sustainable development of major professional households, and understand the importance of financing for green agricultural production, the government should promote the new pattern of "green product" modern agricultural development, pay attention to the publicity work on ecological protection and sustainable development, and improve professional large-scale households. The awareness of the importance of developing green agricultural products enables large professional households to truly understand the connotation of the concept of "strong agriculture, beautiful rural areas, and rich farmers" and creates a good ideological foundation and a social atmosphere for active participation in financing for large professional households in green production financing.

(3) Strengthen the promotion and publicity of green agriculture. The government should promote the new pattern of "green product" modern agricultural development, pay attention to the publicity of ecological protection and sustainable development, raise awareness of the importance of developing green agricultural products among major professional households, and truly understand "strong agriculture, beautiful rural areas, and rich farmers" concept meaning. Second, the government should effectively implement preferential policies and financial subsidies for large professional households to participate in green agricultural production, expand financing channels, accelerate the development of small- and medium-sized rural financial systems, and develop new types of rural financial institutions such as rural cooperatives, village banks, and loan companies. Credit cooperatives in the core position should actively implement the strategy of strategic transformation, increase financial support, invest a certain amount of funds as special funds for the development of large professional households engaged in green agricultural production, and promote the revitalization of rural green industries. Finally, the government should focus on developing a social atmosphere of ecological security and resource protection, speed up the development of the green agricultural value chain, and further develop the industrialized management of green agriculture. In order to promote the development plan of green industry and improve the production efficiency of green agricultural products for professional large-scale households, the Heilongjiang Provincial Government should focus on promoting the construction of marketing channels for green agricultural products, promoting the new online "Internet+" marketing method, and developing online e-commerce platforms and green agricultural products trading display The platform creates a good ideological foundation and a social atmosphere for actively participating in financing for large professional green production financing.

Data availability statement

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the (patients/participants OR patients/participants legal guardian/next of kin) was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

SZ: conceptualization, methodology, and software. XX: data curation and writing—original draft preparation. JL: writing—reviewing and supervision. NW: software. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Can carbon labels encourage green food choices?

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Introduction: A conventionally grown kiwi from Spain or an organic pineapple from Ghana? Which is the more environmentally friendly option? Given that the production and distribution of food is responsible for about a quarter of our CO_2e emissions and thus plays a role in climate change the answer to such questions and, accordingly, making the right food product choices is crucial. The problem, however, is that it is difficult for consumers to calculate the CO_2e value of food as it depends on several specifications such as the type of food, origin, etc. Could carbon labeling of food circumvent this problem and help consumers make more environmentally friendly choices?

Methods: In an online experiment, 402 participants had to choose 20 food products from a fictitious online shop. The participants were randomly assigned to either one of three food labeling conditions (Star Rating, Green Foot, and Traffic Light Label, short TLL) or the control condition.

Results: The labeling conditions resulted in lower overall CO_2e emissions, the purchase of more green food products and fewer red food products than in the control condition. The TLL outperformed the other two labels and was also the most accepted.

Discussion: The carbon TLL is therefore a promising intervention to help consumers to not only choose more environmentally friendly foods, but also make a significant contribution to the fight against climate change.

KEYWORDS

food product choices, carbon label, CO_2e emissions, sustainability, label design

1. Introduction

Kiwi or pineapple? Because you care about the environment, you want to choose the product that has the smallest *carbon footprint*. However, for its calculation, one needs several specifications for each product, such as how (e.g., organic) and where (e.g., Switzerland) it was produced, how it was transported (e.g., by air to overseas) and how it was preserved (e.g., canned; Poore and Nemecek, 2018; Rogissart et al., 2019). These specifications must then be weighted according to their importance and summed up. The food with the lower value should then be chosen. Given the *complexity* of this calculation, and to reduce the cognitive effort involved, consumers instead use simple heuristics (e.g., "whether the product comes from the region or not") to choose between different food options (see Thøgersen et al., 2012, on organic food choices or Scheibehenne et al., 2007,

on food choices in general). Nevertheless, research has shown that consumers' carbon footprint *estimates* are far from accurate, especially for foods with a high carbon footprint, such as meat or dairy products (see Camilleri et al., 2019, or Shi et al., 2018). This has consequences given that 20–40% of our carbon emissions are food related (see Poore and Nemecek, 2018). Improving consumers' ability to assess the carbon footprint of food is therefore key to encouraging consumers to buy more environmentally friendly food (Feucht and Zander, 2017).

One way to achieve this is through the introduction of *carbon labels*, especially since this is also widely supported by consumers (Carbon Trust, 2020). Therefore, in the recent years, different types of carbon labels have been developed and launched on the market. For example, the Eco Label index[1] alone already lists 455 different eco labels, of which about 35 are carbon labels (and there are still some missing from this list). To distinguish between the different types of carbon labels, several classification systems have been proposed (see Schaefer and Blanke, 2014; Thøgersen and Nielsen, 2016; Meyerding et al., 2019; Lemken et al., 2021; Taufique et al., 2022). Taufique et al. (2022), for example, suggested a classification into 4 types of carbon labels: *certificate*, *ordinal rating*, *quantitative* and *ordinal plus quantitative rating* labels.

2. Background literature on carbon labels

2.1. Types of existing carbon labels

Certificate labels show consumers that either the product's carbon footprint has been offset by the company that manufactured it, that the company that manufactured the product has stated that it will reduce its carbon footprint, or that the carbon footprint of that company's product is less than that of a comparable product (those are the most common variants of certificate labels). Hence, such labels can only be attached to certified products. One such certificate label is the *Climatop label* (see Myclimate, 2022, a similar mock-up label is displayed in Figure 1A) which was introduced in Switzerland in 2008 (similar labels are used in Thailand or the United States; see Liu et al., 2016). The Climatop label shows that the certified product, for example, a particular cream, has a lower footprint than comparable creams. Unlike most certificate labels (e.g., Climatop), *ordinal rating labels* could be attached to all products because they show a product's overall carbon footprint by using, for example, a *star rating system* (e.g., from 0 stars = high emissions to 5 stars = low emissions; similar to a hotel rating) or a color-coding system (e.g., green = low emissions, orange = medium emissions, red = high emissions; so called Traffic Light Labels). One such ordinal rating label using a star rating system is the *M-Check* (a similar mock-up label is displayed in Figure 1B) which was introduced by Switzerland's largest grocery retailer the Migros cooperation in 2021 (see Migros, 2022). *Quantitative labels,* unlike ordinal rating labels, show a product's carbon footprint not by its membership in a particular ordinal category (e.g., 3 stars or orange), but by its effective CO_2e emissions in g (e.g., 330 g; a similar mock-up label is displayed in Figure 1C). One such quantitative label is the Carbon Trust label, which was introduced in the United Kingdom. Similar labels exist in Taiwan, South Korea, and Japan (see Liu et al., 2016). What is unique about the Japanese label is that it also includes a pie chart showing where (production, distribution, etc.) the emissions come from in percentage terms (see EcoLeaf, 2022). The *ordinal plus quantitative rating* label, the last type of label, combines the ordinal rating label and the quantitative label. It shows not only the ordinal category in which the product's emissions fall, but also the exact CO_2e emissions of the product. One such *ordinal plus quantitative rating* label is the "indice carbone" of the French supermarket chain Casino (a similar mock-up label is displayed in Figure 1D).

2.2. Behavioral effects of carbon labels

Despite the large number and wide variety of existing labels, only a few studies examine their effectiveness in guiding consumers towards lower carbon food choices, particularly in the area of *grocery shopping*. One of these is the study by Vanclay et al. (2011), which examined whether the last type of label (i.e., the *ordinal plus quantitative rating label*), a so-called Traffic Light Label (TLL), attached to 37 products with high turnover in a supermarket, influenced their purchase. The TLL color (green, yellow, *black*) of a product was determined by comparing the carbon footprint of that product (e.g., a specific butter) to the average carbon footprint of other products in the same category (e.g., other butters). For example, if the product's carbon footprint was below this average, it received a green label. Whether this so-called *relative color coding* is the best method is unclear. Nevertheless, the authors found a substantial, but non-significant *decrease* of sales (from 32 to 26%) of high carbon footprint (black labeled) products and a non-significant increase of sales (from 53 to 57%) of green labeled products. However, when the labeled products were also the *cheapest* (e.g., in the case of butter), a significant 20% increase in the purchase of green labeled products was observed. Although the effects in this study were small, the labels did appear to have an effect. Some more studies testing the impact of carbon labels on food choices are found in the *restaurant* area. Here too, carbon labels lead people to choose more environmentally friendly menus (see Brunner et al., 2018, or Visschers and Siegrist, 2015). But again, the observed effects were small (around 4 to 8%), and Spaargaren et al. (2013) only found an effect when labels were colored and supplemented with other information (e.g., posters) about the carbon impacts of food.

The question arises why is the impact of carbon labeling rather small? If you have to choose between *a kiwi and a pineapple*, environmental friendliness is only one of the many specifications to consider, along with price, for example. Accordingly, using a discrete choice experiment, Thøgersen and Nielsen (2016) showed

1 https://www.ecolabelindex.com/ecolabels/

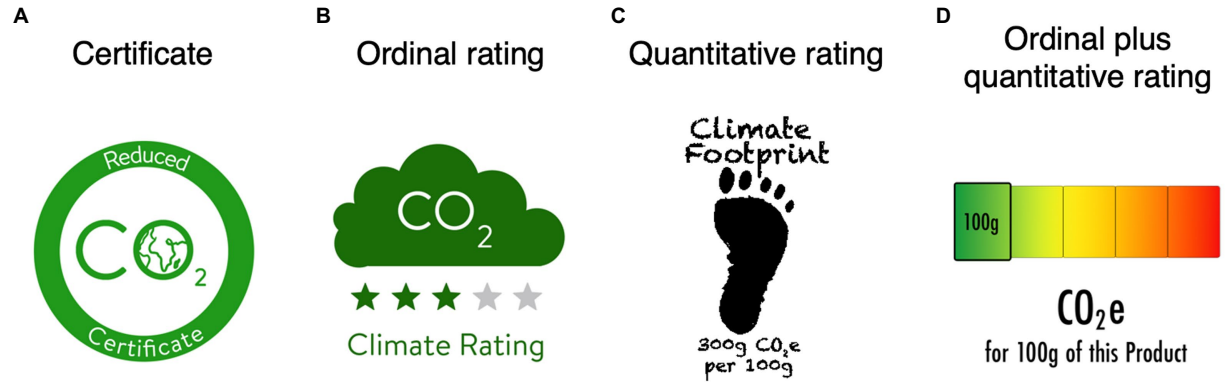

FIGURE 1
Mock-ups of stereotypical labels that capture various design elements commonly used in the four label types: **(A)** certificate label, **(B)** ordinal rating label, **(C)** a quantitative label, and **(D)** an ordinal plus quantitative rating label.

that consumers' choice, in this case for ground coffee, was more influenced by the price of the product and the presence of an organic label than by a *carbon label*. Nevertheless, the carbon label had a positive impact on choice (see also Hartikainen et al., 2014; Hieke et al., 2015; Feucht and Zander, 2017; Dihr et al., 2021, or Meyerding et al., 2019). Additionally, Thøgersen and Nielsen (2016) showed that their *colored* version of the label (i.e., an ordinal plus quantitative rating label) performed better than the one without colors, which accordingly only showed the CO_2e content in g (i.e., a quantitative label). A similar result was observed in the study by Meyerding et al. (2019), who also used a discrete choice experiment to examine how 6 different labels affected tomato choices. Similarly, they found not only that colored labels were more effective than labels without color, but additionally that a simple TLL was as effective or more effective than more complex labels.

In summary, although research has shown that carbon labels can influence purchase decisions see also the reviews of carbon labels by Potter et al. (2021), Rondoni and Grasso (2021), Taufique et al. (2022) there is, in the words of Thøgersen and Nielsen (2016), "a lack of research on how to increase the effectiveness of such a label by optimizing its design" (p. 87).

3. Improvement of carbon labels

3.1. Relevant design elements

However, what could such *design elements* be? Typically, consumers spend only a few seconds on food choices. For example, 5 s for a milk decision in a realistic scenario, a grocery store, (see Thøgersen et al., 2012) or even only 500 ms for a binary decision of the preferred product from two products displayed on a computer screen (see Mormann et al., 2011). The speed of decision-making confirms that consumers' food choices are not based on slow-moving, complex calculations, that require cognitive resources, but on the application of fast-moving, simple heuristics and cues (see Thøgersen et al., 2012; or Scheibehenne et al., 2007), primarily like the price rather than the carbon footprint of the products (Thøgersen and Nielsen, 2016; Meyerding et al., 2019; Carbon Trust, 2020). Accordingly, the eye-tracking study by Beattie et al. (2010) showed that consumers did not look at the carbon label first in 93% of the cases. Hence, they concluded that carbon labels must first and foremost become more *salient*.

Grocery shopping corresponds to a *visual search* for a specific target object (e.g., kiwi) in a scene cluttered with a variable number of other distracting objects (other fruits). It has been shown in laboratory experiments that *color* is the object's feature that can most efficiently guide attention to the target object (see Wolfe and Horowitz, 2004). In this respect, the colors red, yellow, and green perform better than the colors blue and purple (see Lindsey et al., 2010). In addition, *colors* seem to have an effect on people's *emotions*. For example, red seems to be associated with *negative* words (e.g., worse), whereas green is associated with *positive* words (e.g., best, see Moller et al., 2009; Pravossoudovitch et al., 2014). This makes perfect sense, because red is used in everyday life to *signal danger*, for example in warnings or stop signals. In addition, natural hazards such as fires are also red. Green, on the other hand, is used to signify something *positive*, such as safety, or go signals. In addition, growth in nature is green (see Moller et al., 2009). In a qualitative study by Carrero et al. (2021) where participants were asked about the emotions evoked by red and green carbon labels, said associations were confirmed by the participants. However, for grey/black colored labels e.g., the black Carbon Trust label or the TLL using black instead of red by Vanclay et al. (2011) participants' associations were ambiguous (see also Pravossoudovitch et al., 2014, about reaction time and grey colored words). Accordingly, carbon labels should use colors or, more precisely, traffic-light colors (red, orange/yellow, green) because colors not only attract consumers' attention, but also convey a message (see Thøgersen and Nielsen, 2016).

Accordingly, studies in the *healthy food* domain have already shown that traffic light colors work not only better than other colors (e.g., purple, white, blue; Van Epps et al., 2021) but also, for example, as star ratings (e.g., Health Star Rating System; Egnell et al., 2020). Star ratings appear to influence food choices only

when a corresponding color is added (e.g., green for 5 stars; Pettigrew et al., 2020). To our knowledge, such studies or findings do not yet exist with respect to carbon labels.

In addition, carbon labels should be *easy* to understand. As mentioned, humans do not like to make complicated calculations. This is also shown when people have to assess (calculate) the healthiness of a food by weighing and adding up the different nutritional information such as fat, sugar, etc. Furthermore, it has been shown that, for example, the weighing itself can be slightly changed depending on the context (see Reijnen et al., 2019). Accordingly, it has been found that so-called summary labels (indicating the final product of the calculation by, for example, a color), attached to the front of the package, help consumers to recognize healthier products (see Hagmann and Siegrist, 2020).

This simplification is also the idea behind carbon labels. However, consumers still find certain carbon labels too difficult to understand. For example, in the study by Carrero et al. (2021), consumers thought that the carbon labels tested showed (dangerous) ingredients. It is possible that the label design showing a cloud with the words "CO_2" triggered such an association. Overall, consumers appear to find the carbon TLL with red to green colors easier to understand, more helpful in the decision-making process, and more popular than the original carbon trust label or a TLL with black rather than red for high carbon products (Sharp and Wheeler, 2013).

In summary, we suggest that labels should be designed according to the principles of Attractive, Easy and Timely. In other words, they should be Attractive by attracting attention and providing information in an appealing design. Easy by being easy to understand. This by using symbolic language such as colors and signs that are commonly known and make the products easy to compare. Finally, they should be Timely by displaying the information at the moment of decision. This can be achieved by placing labels on the front of the package, as eye-tracking studies have shown that consumers prefer to pay attention to information on the front of the package (e.g., health claims and labels) than on the back (e.g., nutritional information, see Bartels et al., 2018). These design principles are based on the EAST framework for behavioral interventions (see Hallsworth et al., 2014).

3.2. New types of carbon labels

Based on these design principles, we designed 3 types of labels. The first type of label is the Star Rating Label (see Figure 2) like the M-Check label, which falls into the category of ordinal rating labels. The level of the product's carbon footprint is shown by *0 to 5 stars*. The design was thereby based on the well-known hotel rating system, as well as the Energy Star label used for appliances in many countries. Also added were the words "CO_2" (with the planet symbol in the O) and "in the name of sustainability" on a green background. Accordingly, we also used design elements from existing labels, such as the Climatop label. The second type of label is the TLL (see Figure 2), in which the level of the product's footprint is shown by either a green (low emissions), an orange (medium emissions), or red color (high emissions; see Vanclay et al., 2011; Thøgersen and Nielsen, 2016; Meyerding et al., 2019). This label was designed in collaboration with two designers from the Zurich University of Applied Arts. Contrary to other labels, it was not the foot itself that was colored, but the area around the foot. This allowed more area of the label to be inked, which should enhance the color effects described above. Also, depending on the color of the label, the footprint has a slightly different shape (e.g., green = a lighter print). Furthermore, the words "Carbon Foodprint" and the numerical amount of CO_2e were added. The label thereby falls in the category ordinal plus quantitative rating label. The third type of label is the "Green Foot" label, which falls into the category certificate labels. The design is similar to that of the green TLL, but without the quantitative information on CO_2e emissions. The low emission is shown by the addition "Good Choice." Similar certificate labels are the Climatop or versions of the Carbon Trust label (see Supplementary material 4 for a comparative tabular overview of the labels).

The aim of the study is to answer the question of whether carbon emissions from shopping can be reduced by carbon labels, respectively which newly developed type of label is most effective in this regard. To test this, we designed an online study in which participants were randomly assigned to one of three labeling conditions (type of label: star rating, TLL, green foot) or a control condition with no labeling. Regardless of the condition, participants were presented with 20 different food categories (e.g., pasta, vegetables). Each category contained 6 products - depending on the condition with a specific type of label or not - from which participants had to choose 1 product by putting it in the shopping cart. Thereby we measured, the total carbon emissions of the shopping cart, the average rating of the products chosen in each food category and the number of red, orange and green products chosen. Furthermore, it was investigated which type of labeling is most accepted and which institution should initiate such a labeling regarding its trustworthiness.

4. Materials and methods

4.1. Participants

Four hundred two participants aged 19 to 65 years old (M_{age} = 26.05; SD_{age} = 6.45; 61.7% female) from ZHAW Zurich University of Applied Sciences and the greater area of Zurich took part in this computer-based online study. As an incentive, participants could enter a raffle for one of two iPads (which a total of 79.4% did) or if a student of the ZHAW School of Applied Psychology receive course credit instead (which 6.2% overall did). All participants gave informed consent.

4.2. Stimulus material

As stimulus material served images of 120 food (and beverage) products from 20 different categories: milk, cheese, citrus fruits,

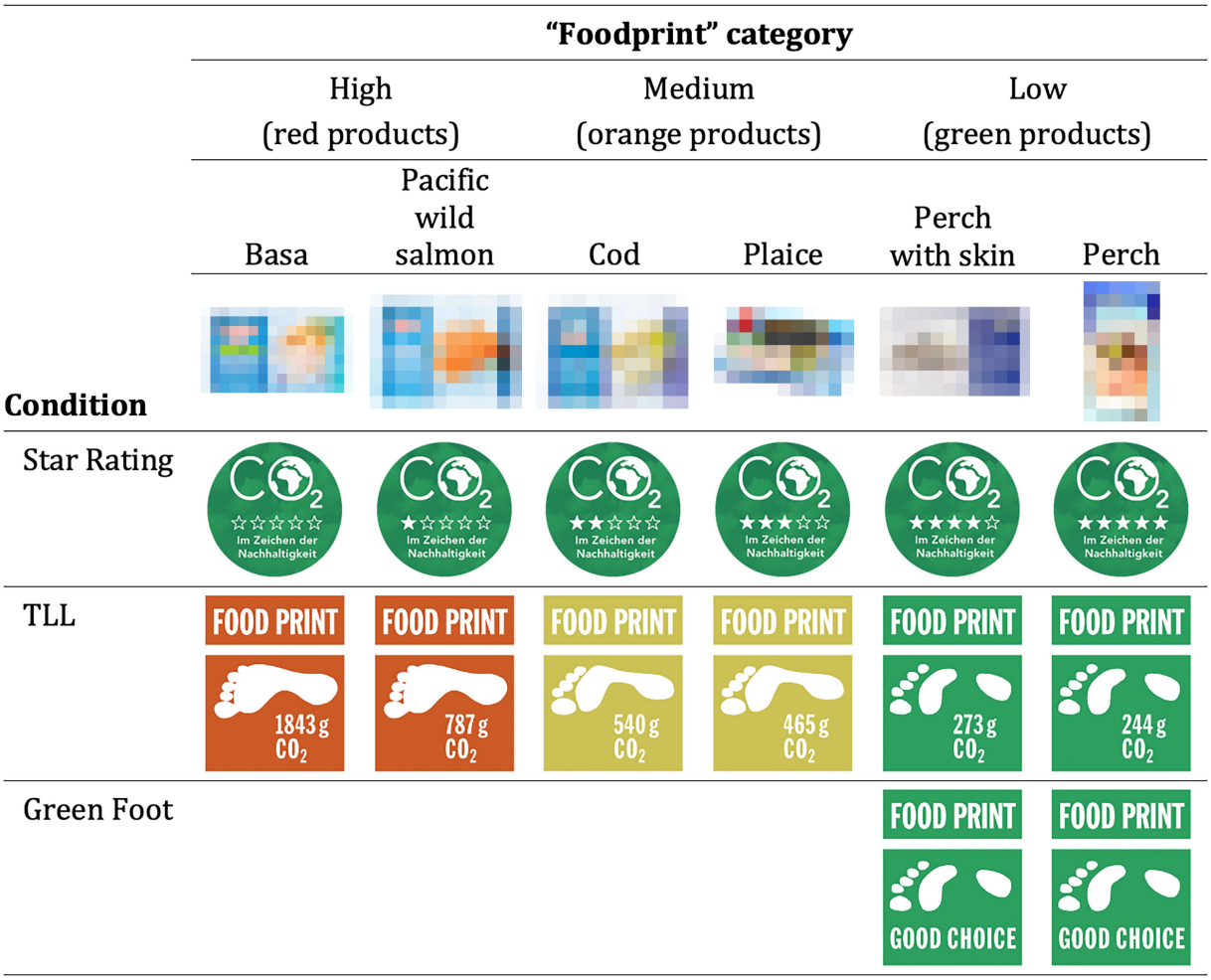

FIGURE 2
Example of the three different labels tested in the product category "fish."

fish, coffee, pasta, rice, sausages, meat, etc. Foods were selected to cover the full range of everyday needs. The images (taken with permission from an online store of one of the largest Swiss retailers) were supplemented with the name, price, quantity as well as several CO_2e relevant specifications of the product (see Figure 2). More precisely, these specifications were: Country of origin (e.g., Switzerland), transport mode (ground or by air), preservation mode (e.g., fresh or dried) and cultivation (organic or conventional) of the product (see eaternity[2] calculator for details). This information was provided to rule out the possibility that the effect of the carbon labels - compared to the control group–was due only to the lack of additional information to calculate CO_2e levels. Depending on which of the four conditions participants were randomly assigned to, they saw either, a grocery shop where none of the products were supplemented with a label (control group), only some products were supplemented with a label (see Green Foot condition), or all products were supplemented with a label (Star Rating and TLL conditions). Since the labels have already been described in detail in the introduction, there are just 2 additions. First, the total number of CO_2e was only shown in the TLL condition, since neither "carbon reduced" labels (e.g., Climatop) nor star rating labels (e.g., Migros M-Check) normally show these numbers. Second, the rating or color coding is relative, that is, per product category (see fish example of Figure 2; according to Vanclay et al. (2011)) and not across all the products.

4.3. Procedure

At the beginning of the study participants had to imagine that they had to buy 20 food products for a housewarming party with friends from a new online shop (here called shop-it). In doing so, they were reminded that as students, they have a limited budget.

2 Unfortunately, the eaternity calculator is not publicly available anymore. The data of the life cycle assessments are based on evaluations of different Universities and other research institutes, see: www.eaternity.org

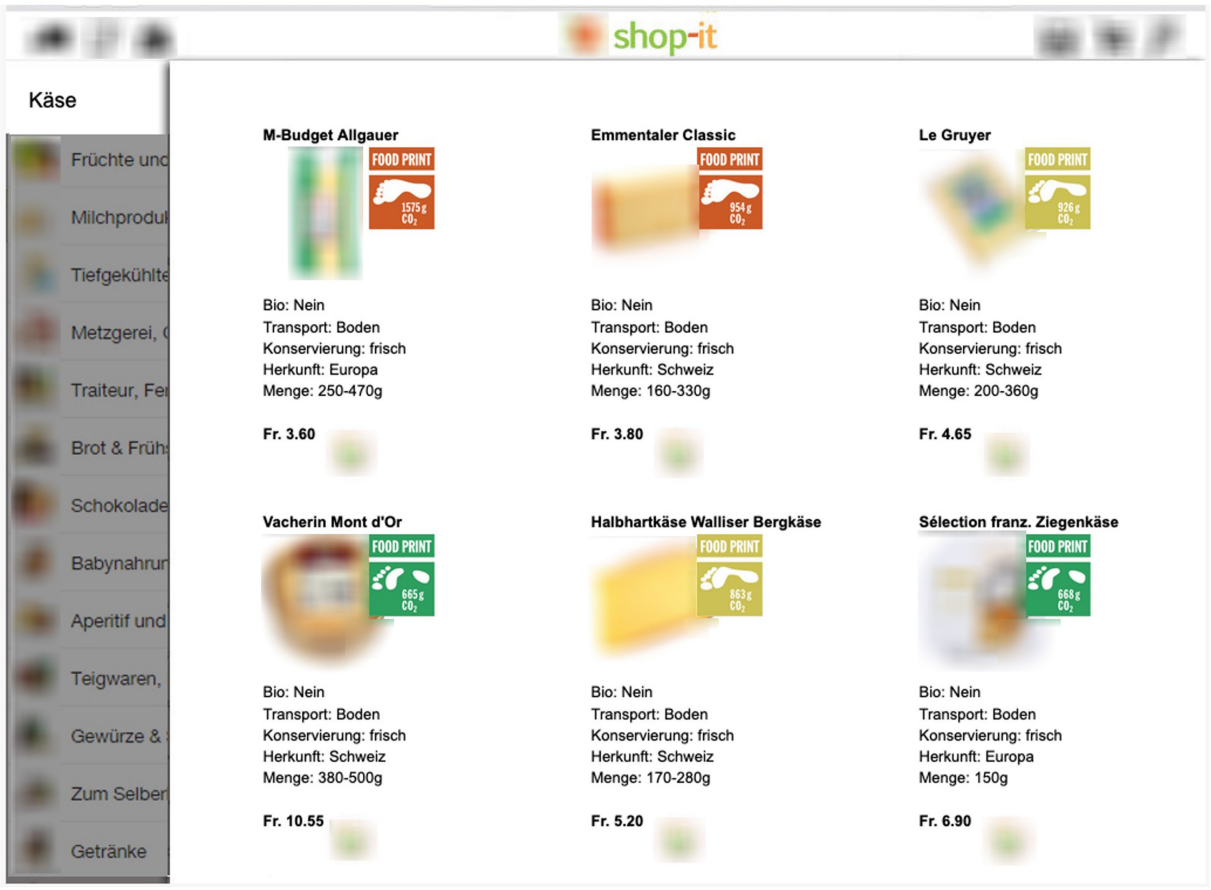

FIGURE 3
Stimulus material. Examples of the choice task in the TLL condition.

Note that nothing was said about sustainability, labels, etc. Participants were then guided through the shop or products by being shown 20 pages (see Figure 3), each containing 6 food products of a particular category (e.g., 6 different cheeses). This was to ensure that all participants saw the same products. Participants could then buy[3] a product by clicking on the shopping basket symbol below each product. The order of the categories was kept constant in all conditions but the position of the products per page was randomized.

After the food shopping task, participants had to answer a series of questions. For example, in the label conditions, there were questions about the acceptance of the corresponding label such as "I consider the CO_2e label to be credible" (on 5-point Likert scales, from-2 "strongly disagree" to 2 "strongly agree"). In addition, all participants had to answer the question as to how trustworthy[4] they would rate labels certified by various institutions such as private companies or the European Union. Trustworthiness in a label is an important factor for its acceptance and previous studies showed that consumers have rather low trust in carbon labels (see Feucht and Zander, 2017). We also included a control question (i.e., an item "Please tick the answer 'Agree' for control purposes") to check the validity of participants' responses. The carbon label questions were taken from Weinrich and Spiller (2016; with their approval) and adapted to our context on carbon footprint labels. Since these questions are not relevant with respect to the aim of the study, we do not address them further. At the end

3 Note, the buying decision was hypothetical. Recent research shows that a hypothetical bias is less likely when it comes to environmental attributes of food. For example, Aoki and Akai (2022) did not find a hypothetical bias in the WTP for carbon emissions in food.

4 A label is considered "trustworthy" if people judge the information (e.g., a claim) provided by the label to be credible. For this assessment, consumers consider cues such as which organization is behind the label (Gorton et al., 2021). If trustworthiness is present, it seems to moderate the impact of a label, that is, whether the consumer considers the label and decides accordingly (see Li et al., 2017). However, if a consumer perceives a label only as "green-washing," it is perceived as less trustworthy (see Ye and Wildschut, 2009), hence making it less effective.

of the study, we assessed participants' demographic data (e.g., age, sex).

Regarding the food shopping task, we first calculate the CO_2e (in g) emissions of the products purchased, that is, of those products that ended up in the shopping basket. The CO_2e of a product was thereby calculated per 100 g. Second, we rated the products within each food category by the number of stars they would have received under the Star Rating label condition (0 = high emission, to 5 = low emission). This scale made it possible to assess if labels affect choices differently in each of the categories. This way of rating makes comparisons easier as the different categories have large differences in the mean and range of their carbon footprint (for example meat from 486 g to 7,287 g CO_2e, but citrus fruits only from 24 g to 61 g CO_2e). Third, we calculated the number of products purchased within the high (red), medium (orange), and low (green) footprint categories.

5. Results

5.1. Participants excluded

From the 449 participants that completed the study, 33 participants (7.3%) who needed less than 10 or more than 60 min to complete the study were excluded from the analysis. Furthermore, 14 participants (3.1%) who did not answer the control question correctly were excluded.

5.2. Shopping task

5.2.1. Overall CO_2e emissions (in g)

A *planned contrast* (under a one-way ANOVA) showed that the total g CO_2e of the products bought in the no label (control) condition was significantly higher than in the label conditions (Star Rating, TLL, Green Foot), $t(398) = 3.76$, $p < 0.001$, $d = 0.44$. Tukey adjusted post-hoc tests showed a significant difference between the control condition and: the Star Rating label condition, $t(398) = 2.73$, $p < 0.05$, and the TLL condition, $t(398) = 4.75$, $p < 0.001$, but not the Green Foot label condition, $t(398) = 1.81$, $p = 0.27$. Within the label conditions, there was only a significant difference between the TLL condition and the Green Foot Label condition, $t(398) = 3.01$, $p < 0.05$ (all other comparisons were not significant: $t < 2.13$, $p > 0.14$; see Table 1 for the specific values). Overall, this suggests that the TLL is the most beneficial and the Green Foot label the least beneficial label in terms of total g CO_2e reduction (see Figure 4A).

5.2.2. Label effects per category (measured with the carbon star rating)

A repeated measure ANOVA showed a significant main effect for condition (labels and no label), $F(3, 398) = 14.15$, $p < 0.001$, $\eta^2 = 0.10$, as well as a category, $F(19, 7{,}562) = 41.51$, $p < 0.001$, $\eta^2 = 0.09$, but no significant Condition × Category interaction, $F(57, 7{,}562) = 1.07$, $p = 0.33$. Tukey adjusted post-hoc tests showed again a significant difference between the control condition and: the Star Rating label condition, $t(398) = 3.86$, $p < 0.001$, and the TLL condition, $t(398) = 6.30$, $p < 0.001$, but not the Green Foot label condition, $t(398) = 2.23$, $p = 0.16$. Within the label conditions, there was only a significant difference between the TLL condition and the Green Foot Label condition, $t(398) = 4.16$, $p < 0.001$ (all other comparisons were not significant: $t < 2.57$, $p > 0.06$). These results are thereby in line with the results of overall CO_2e emission (in g) calculations and show that labels have an effect on choice. Though the labels had no differential effect per category (no interaction), there are differences between the categories (see Figure 4C). However, this seems to be more due to differences in preference of certain products. Thus, participants in the control condition already preferred products with low carbon emissions in some food categories (e.g., citrus) and products with high emissions in other categories (e.g., fish). Nevertheless, the results suggest that labels can have a positive effect regardless of category.

5.2.3. Number of products purchased per footprint category

Do labels affect product purchases (compared to the control group) differently in the red (high), orange (medium), or green (low) footprint categories, and if so, how (see also Table 1)? To investigate this, we conducted a multinominal regression analysis with Tukey adjusted contrasts.

The calculated regression was significant, $\chi^2\ (6) = 115.75$, $p < 0.001$, $R^2 = 0.02$, indicating a differential label effect regarding the purchase of green, orange, and red products. The subsequently calculated planned contrasts, for example, showed that all label conditions led participants to purchase *more green* products than in the control condition (Star Rating label condition: $t(8) = 5.44$, $p < 0.01$; TLL condition: $t(8) = 8.91$, $p < 0.001$; Green Foot label condition: $t(8) = 4.58$, $p < 0.01$). Within the label conditions regarding green choices, there was a significant difference between the TLL condition and Green Foot condition, $t(8) = 4.54$, $p < 0.01$, and the TLL condition and the Star Rating label condition, $t(8) = 3.65$, $p < 0.05$, but not between Star Rating condition and Green Foot label condition, $t(8) = 0.84$, $p = 0.83$. However, in the *orange* category, there were no differences in products purchased between the label conditions and the control condition, or between the label conditions themselves (all $t < 2.29$, $p > 0.17$). Finally, the Star Rating label condition, $t(8) = -3.75$, $p < 0.05$, and the TLL condition, $t(8) = -8.79$, $p < 0.001$, but not the Green Foot label condition, $t(8) = -2.20$, $p = 0.21$, made participants buy *less red* products compared to the control condition. As regards the green products, differences between the labels were significant between the TLL condition and the Star Rating condition, $t(8) = 5.26$, $p < 0.01$, and the TLL condition and the Green Foot label condition, $t(8) = 6.77$, $p < 0.001$, but not between the Star Rating condition and the Green Foot label condition, $t(8) = 1.57$, $p = 0.44$. Accordingly, the labels, especially the TLL, had a positive effect in the green (more purchases) and in the red (less purchases) footprint category (see Figure 4B).

TABLE 1 Outcome measures for the shopping task per condition.

Measure		Control (*N*=95)	Star rating (*N*=106)	TLL (*N*=99)	Green foot (*N*=102)
CO_2e (in *g*)		13′992.7[a] (3′740.0)	12′645.4[b,c] (3′984.3)	11′366.2[b] (4′069.6)	12′985.2[a,c] (4′297.6)
Footprint (in number of products bought)	Green	4.32[a] (1.97)	5.86[b] (2.85)	6.84[c] (3.18)	5.47[b] (2.54)
	Orange	7.52[a] (2.18)	7.14[a] (2.27)	7.69[a] (2.53)	6.98[a] (2.11)
	Red	8.17[a] (2.70)	7.00[b] (3.25)	5.47[c] (3.37)	7.55[a,b] (3.15)

Standard deviations are given in parentheses. Letters indicate Tukey-adjusted comparisons; same letters indicate that no significant difference between conditions exists.

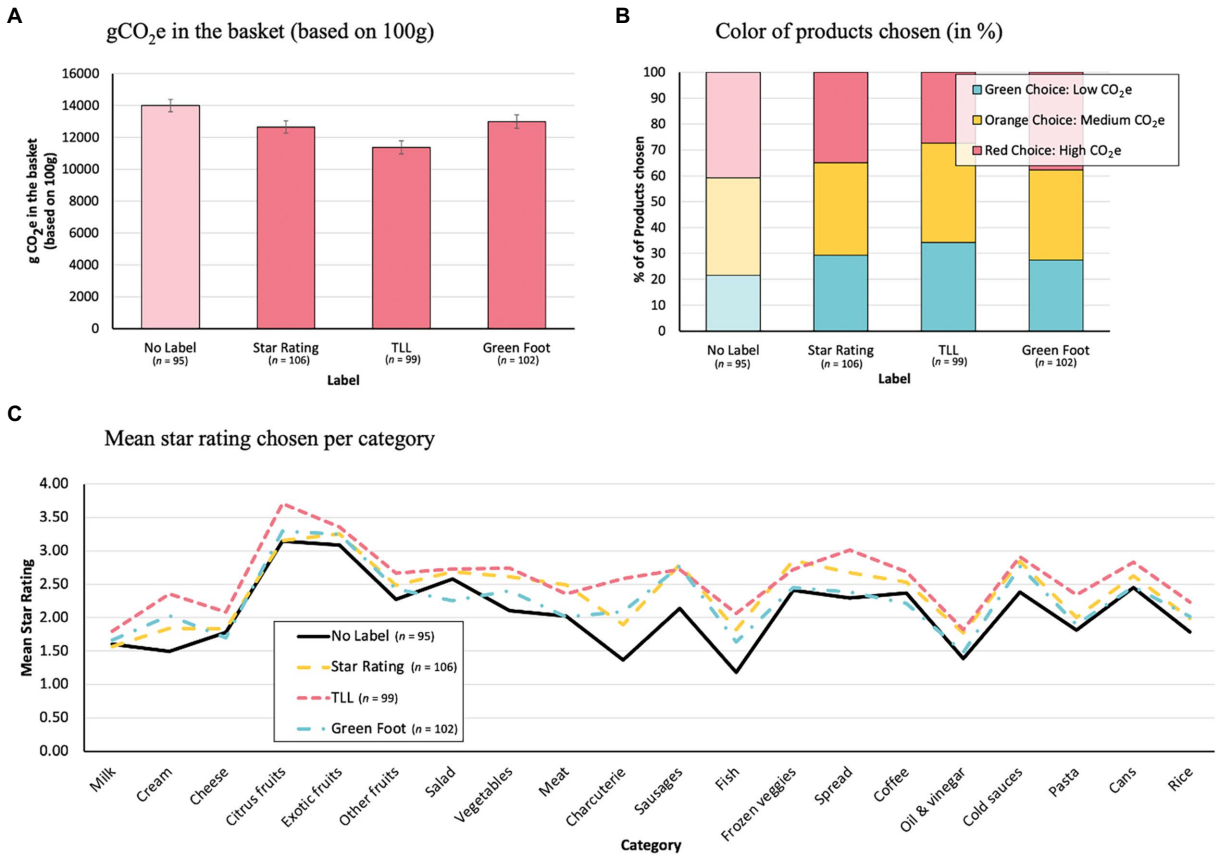

FIGURE 4
Results of the different outcome measures: **(A)** gCO_2e of the products (based on 100g) in the shopping basket, **(B)** color of the product chosen in %, **(C)** mean star rating of the products chosen in each category.

However, no significant effects could be found for any of the labels in the orange footprint category.

5.3. Questions

5.3.1. Label acceptance

The overall consistency of the questions was good ($\alpha = 0.86$, item loadings from 0.46 to 0.80). A calculated one-way ANOVA showed a significant main effect for condition (note, only the three label groups saw these questions), $F(2, 304) = 5.06$, $p < 0.01$, $\eta^2 = 0.032$. Tukey adjusted post-hoc tests showed significant differences between the Star Rating label ($M = -0.06$, $SD = 0.76$) and the TLL ($M = 0.22$, $SD = 0.71$), $t(304) = 2.83$, $p < 0.05$, and the TLL and the Green Foot label ($M = -0.05$, $SD = 0.64$), $t(304) = 2.70$, $p < 0.05$, but not between the Star Rating and the Green Foot label, $t(304) = 0.11$, $p = 0.99$. Overall, participants' label acceptance was highest for the TLL, although the effect is rather small. The translated questions and means are shown in Supplementary Table 1.

5.3.2. Controlling institution

There was a significant effect regarding trustworthiness of the controlling institution, $F(5, 1{,}530) = 127.61$, $p < 0.01$, $\eta^2 = 0.29$. Participants regarded a carbon label awarded by the State (i.e.,

Switzerland, $M = 0.84$, $SD = 0.67$) and the WWF ($M = 0.71$, $SD = 1.04$) as most trustworthy. Tukey-adjusted post-hoc tests found no difference between these two institutions, $t(306) = 2.50$, $p = 0.13$. Comparably (i.e., State and WWF), lower values of trustworthiness could be found for the federation of Swiss food industry ($M = 0.31$, $SD = 1.04$), the EU ($M = 0.25$, $SD = 0.93$), private companies ($M = -0.06$, $SD = 1.02$) and international corporations ($M = -0.51$, $SD = 1.02$; all $t < 5.62$, $p < 0.001$). For a graphical representation see Supplementary Figure 1.

6. Discussion

Overall, our results show that *carbon labels* make consumers choose more environmentally friendly food products, especially under the *TLL*, an *ordinal plus quantitative rating* label. The TLL resulted in the largest reduction in *overall CO_2e emissions* (in g), shown by the purchase of more *green* (e.g., low carbon footprint meat such as chicken) and less *red* (e.g., high carbon footprint meat such as beef) products. Thus, these results are consistent with those of existing research (see Vanclay et al., 2011; Thøgersen and Nielsen, 2016; Meyerding et al., 2019). The other labels, the *Green Foot* (a certificate label) and also the *Star Rating* label (an ordinal rating label) showed similar, albeit weaker, effects. Finally, TLL affected choice in all food categories and was also the most widely accepted by participants. Unlike other studies, in this study, not only was the effectiveness of multiple carbon labels (3 labels) tested simultaneously, but they were also tested among a broader range of products instead of just one, such as coffee or tomatoes (Thøgersen and Nielsen, 2016; Meyerding et al., 2019, respectively), or a few products [four categories in Vanclay et al. (2011)] and in a new setting, a realistic online shopping scenario.

However, despite the proven effectiveness of carbon labels, there are still some critical aspects in this regard that need further investigation:

6.1. Reference frame for reporting carbon emissions

For example, our labels show CO_2e emissions in grams *per 100 g* (or 100 ml) of a product. Alternatively, you could do this per *serving size* or *package size*. For example, 100 ml of wine, which is also considered a serving size in Switzerland, has about 360 g CO_2e, whereas 100 ml of beer has only 115 g CO_2e (Saxe, 2010). However, a standard size of beer is usually 250 ml, which then leads to the higher CO_2e footprint of 287 g CO_2e, which is then comparable with wine. Which measure is better is still up for debate. Regarding healthy food labels, the 100 g comparison is nowadays the most widely used (e.g., Nutri-Score, TLL, or the Chilean warning label). This is because specifying by portion size has the disadvantage that non-standard portion sizes can easily be reduced by the retailer to make the values turn out better. This could also happen with carbon labels by offering, for example, smaller package sizes. People would then probably buy several small packages, which is no better than buying one large package. Out of curiosity, we ran our analysis again, taking package sizes into account. For example, if a participant chose the 150 g goat cheese, the value of 1,002 g CO_2e instead of 668 g CO_2e was newly included in the calculation. The label effects found were similar, indicating that the effect of carbon labels per 100 g is maintained even when differences in package size are considered (see Supplementary material 3 for more information).

6.2. Reference frame for color coding

Similar to Vanclay et al. (2011), and also Muller et al. (2019), the color of a product's carbon label was determined relative to the average emissions of the other products in the same category (i.e., relative color coding). This approach is based on the idea that consumers usually choose between products (e.g., different types of cheese) of the same category when making food decisions and the label should accordingly guide them to, for example, the cheese with the lowest carbon footprint. This seems feasible as a color coding across all products as for example the logo of Raisio (2022) would make it difficult to select an environmentally friendly cheese, for example, as most of them would get the color red. The downside, however, is that consumers could be left with the impression that a green product in one category (e.g., meat) is just as carbon friendly as a green product in another category (e.g., fish). This could then lead to, for example, increased purchase of green-labeled products in a high-carbon category such as meat. Note that this has not yet been documented for relative color coding, so these assumptions are so far only speculative. Although, the results of Brunner et al.'s (2018) study on menu choice suggest that may even cross-product color coding could lead to such effects.[5]

6.3. Aspects included in the calculation of the label

Most carbon labels – like ours – do not consider the impacts on, for example, biodiversity or water use (see the eaternity label[6], for a label that does). Whether the consideration of these further characteristics has an additional benefit is still under discussion (little benefit has been reported when characteristics strongly correlate with each other, see Muller et al., 2019). It is

5 In Brunner et al. (2018) study on days on which a green labeled meat dish was available, sales of this meat dish increased, and sales of the green labeled fish dish decreased, which resulted in a higher carbon footprint overall.

6 www.eaternity.org

also unclear whether it is better to report a separate value for each characteristic (see eaternity label) or a total value averaged over all characteristics [as suggested by Foundation Earth (2022)]. The total value, however, offers the possibility of manipulation, since a bad value on one characteristic can be compensated with a good value on another characteristic. This is what happened with the Nutri-Score health label, where Nestlé, for example, changed the recipe of its Nesquik cereals to give them a Nutri-Score score of A (instead of C, see Nestlé, 2021). However, since the sugar content is still very high (22 g per 100 g), it cannot be considered a healthy cereal. On the other hand, if you have to integrate the values of several characteristics into a single total value, you can easily be misled. This was found not only for healthy food labels (see Reijnen et al., 2019), but also in the study by Meyerding et al. (2019), where products with a lower overall carbon footprint but orange, green, and red ratings for various CO_2e-related attributes influenced purchase decisions less than a label with a higher overall footprint.[7]

Negative labeling. In contrast to all the approaches mentioned so far, one could think about labeling only those products that have a high carbon footprint or even poor scores on other attributes such as biodiversity. Although there are no studies to date examining the impact of red/black traffic light labels attached only to products with high carbon footprints, there is evidence that negative labels may influence purchasing decisions more than positive ones (Grankvist et al., 2004; Meyerding et al., 2019).[8] For example, Van Dam and De Jonge (2015) found that a non-organic label applied to conventionally produced products led to a higher preference for organic food than an organic label applied to organic food. The larger effect for negative labels can be explained by loss aversion, in which people weigh the risk of a negative outcome more heavily than that of a positive one (Kahneman and Tversky, 1979). The results of our study do not show a superior effect of negative labeling, only that TLL overall are more effective than labeling just green products with a certificate label.

In terms of limitations, one could cite the usual concerns about online studies (i.e., external validity) and the appropriateness of the sample (i.e., students). Another limitation could be that we did not record whether participants understood the meaning of the different terms. For example, Hartikainen et al. (2014) found that participants were unaware that labels assess CO_2e emissions. Perhaps carbon labels influence choice even if consumers do not really understand the concept behind the label, but as the study by Li et al. (2017) shows, carbon labels affect consumers more when they understand it. We therefore propose to complement the simple TLL with a QR code that directs to a website or app where additional information about the product and the calculation of the carbon label can be found (this analogous to websites such as[9] or[10]). Thereby the carbon label and the websites should be administrated by an organization such as the WWF or the state, as they are perceived as most trustworthy in our study (see also Thøgersen and Nielsen, 2016) and trustworthiness seems to affect the effectiveness of carbon labels (see Li et al., 2017).

Overall, this study adds to the existing carbon label literature by testing in a shopping task, three different label formats, whereby two have to our knowledge not been empirically tested so far (carbon certificate label and rating label without color). The study underpins the findings of other authors that carbon TLLs are more accepted and more effective than other labels tested so far. We also identified research gaps, such as a lack of research about the influence of the reference frame on TLL's effectiveness, or a lack of research about negative carbon labels. Nevertheless, well designed carbon labels can influence decision making and lead consumers to carbon friendlier food choices.

Data availability statement

The datasets presented in this article are not readily available because only aggregated data are shared. Requests to access the datasets should be directed to swen.kuehne@zhaw.ch.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

SK and ER: made an equal substantial, direct, and intellectual contribution in all stages of the work. LLV and MB: were involved in the design and programming of the study. All authors contributed to the article and approved the submitted version.

7 Note, in the study of Meyerding et al. (2019) a label with an orange aggregation footprint, a green overall and a red reduction footprint had a lower part-worth utility than a label where all footprints were orange, although the actual carbon footprint was lower for the first label.

8 Note, Meyerding et al. (2019) found higher part-worth utilities in the CBCA for red then for green labels. Grankvist et al. (2004) found that participants with intermediate environmental concerns are especially affected by red labels, whereby participants with high environmental concerns are affected equally by green and red labels. People with low environmental concerns were not affected by the labels at all.

9 www.codecheck.info

10 www.openfoodfacts.org

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.902869/full#supplementary-material

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The relationship between student's perceptions of their school environment and academic achievement

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Research within an educational context has demonstrated the importance of variables such as socioeconomic status, gender and school attendance as predictors of academic achievement, however research investigating the role of the physical learning environment on academic achievement is more limited and what research has been conducted often focuses on objective characteristics such as temperature, air quality and noise. In contrast this study measures students' subjective perceptions of their physical school environment and explores how these perceptions along with socioeconomic status, gender and school attendance relate to academic achievement. In addition, we also examined a range of other important variables that could be potential mediating factors between environmental perceptions and academic achievement. The study was conducted with 441, S5 students in five secondary schools in Scotland. Students completed a questionnaire that measured their perceptions of their school environment, their behavior in school, and their learning goals. In addition, data on student academic achievement, attendance and socioeconomic status was provided by the Local Authority. Regression analysis indicates that students' subjective perceptions of their physical school environment, along with attendance, socioeconomic status and gender are all significantly related to academic achievement. In addition, subsequent analysis indicates that the relationship between students' subjective perceptions of their physical school environment and academic achievement is mediated by important "in-school behaviours," namely engaging behavior and environmental difficulty. The implications of these findings are discussed in terms of the direct and indirect relationship between student perceptions of their school environment and their academic achievement.

KEYWORDS

physical learning environment, academic achievement, subjective and objective data, attendance, socioeconomic status, gender, school behavior

1. Introduction

Within an educational perspective, research has highlighted a range of factors that can, to a greater or lesser extent, predict student academic achievement. These include student characteristics such as motivation (Pekrun et al., 2017) and self-efficacy (Zimmerman, 2000); school climate (Steinmayr et al., 2018); socioeconomic status (SES) (Liu et al., 2020); gender (Ghazvini and Khajehpour, 2011); parental education (Hotz and Pantano, 2015); and attendance (Gottfried, 2014). In addition, there is also a growing body of research suggesting that the physical learning environment of schools can also predict a range of educational outcomes including academic achievement (Barrett et al., 2015). This paper extends this research by examining how students'

subjective perceptions of their school environment relate to their academic achievement relative to other previously established variables such as SES, gender and attendance.

In comparison with issues such as pedagogical approaches, the role of the physical learning environment within teaching and learning has received less attention within educational research. However, from an environmental psychology perspective, research has demonstrated how physical characteristics of the learning environment are related to a range of student educational outcomes and experiences. These include: student attitudes such as the desire to go to school and a feeling of pride in their school (Rudd et al., 2008); problem behavior such as truancy and drug use (Kumar et al., 2008); students feelings of safety within schools (McEwen et al., 2007); and greater use of "positive" approaches to learning (Edgerton et al., 2011). However, given the focus of this paper, it is pertinent to review research on the impact of physical characteristics of the learning environment on academic achievement.

Relevant characteristics of the physical learning environment can include both psychosocial features and physical features. Research on psychosocial features have shown how the amount of space per child in a classroom (spatial density) can be as important as the number of children in a classroom (class size), and that less space per child negatively impacted on girls' academic achievement and boys' classroom behavior (Maxwell, 2003). Maxwell and Chmielewski (2008), conducted research on classroom personalization and found that attempts to increase the level of student classroom personalization by increasing the amount of student work on display and involving students in designing displays, was shown to enhance the self-esteem of first grade students in an elementary school (Maxwell and Chmielewski, 2008).

Research focusing on specific physical features have shown the importance of lighting within schools, with students under full-spectrum fluorescent lamps with ultraviolet supplements having better educational achievement than students under other artificial lighting conditions (Hathway, 1995). A meta-analysis conducted by Pilcher et al. (2002) concluded that temperature extremes negatively impact performance on a wide range of cognitive-related tasks, with temperatures above (32°C) or below (10°C) resulting in the greatest decrement in performance in comparison to neutral temperature conditions (14.88% decrement and 13.91% decrement, respectively). Research on ventilation levels within schools showed that low (poor) ventilation within classrooms significantly reduced students' attention and negatively affected memory and concentration (Bakó-Biró et al., 2012). Acoustical aspects of learning environments have also been shown to impact on cognitive task performance with "classroom-babble" (noise by children alone) impairing performance on verbal tasks and "classroom babble plus environmental noise" impairing speed of processing tasks (Dockrell and Shield, 2006). A comprehensive, literature review of learning environments and student educational outcomes and experiences, highlighted the effect of physical characteristics of the learning environment, such as air quality and noise, on learning (Higgins et al., 2005). The researchers concluded that while there was clear evidence of a positive effect where the learning environment is brought up to a minimum standard (by improving these characteristics), there was less evidence to support "going beyond" this minimum standard. This view was echoed by Earthman (2004) who argued that while inadequate school buildings contribute to poor student performance, schools might not need to be any more than adequate. Interestingly, Higgins et al. (2005) go on to argue that improving school environments may have less to do with changing specific physical characteristics and more to do with how the change process is managed, in particular attempts to engage with, and involve users.

While this research suggests the importance of different environmental characteristics within learning environments, it also includes some limitations. Firstly, while the outcomes often include performance on important cognitive tasks and abilities such as speed of processing, concentration, and memory, there are relatively few studies that demonstrate how the physical learning environment impacts on student academic achievement. One noticeable exception to this, was a study conducted in primary schools in England by Barrett et al. (2015) which found that differences in levels of stimulation, individualization and naturalness within classrooms, explained 16% of the variance in student learning progress throughout a year. Findings such as these are rare and indicate that it is possible to quantify the impact of the learning environment on student performance and that this impact can be significant.

A second limitation with the previously cited research is the focus on "single-variable" studies. While these have improved our understanding of how specific aspects of a learning environment may impact on students, they do not recognize that the student experience is rarely determined by a single factor but is instead influenced by the combination of multiple factors. This has led to attempts to investigate learning environments that focus on the summative experience of all aspects of the physical learning environment whether this is at the classroom level (Barrett et al., 2015) or at the whole school level (Kumar et al., 2008). This approach reflects a fundamental characteristic of environmental psychology by recognizing that environment-behavior relationships should be viewed as holistic units.

A final limitation with much of the research cited above is the focus on the direct effects of the physical environment using objective measures such as CO2 levels (air quality) decibel levels (acoustics) and temperature levels (thermal comfort). While this approach supports an understanding of causal relationships between physical characteristics of the learning environment and student outcomes, it does not consider the potential indirect or symbolic effect of the physical environment (Weinstein and Woolfolk, 1981), and does not recognize the importance of individual differences and students' subjective experience of their physical learning environment. In contrast, a number of researchers have argued for the need to assess students' perceptions of their learning environments. Using an online survey, Zheng Yang et al. (2013) measured university students' perceptions of their classroom attributes and found that these perceptions were highly dependent on spatial characteristics such as visibility, furniture and ambient characteristics such as air quality and temperature. In addition, these researchers found that non-classroom factors such as gender, added valuable contextual information for understanding student perceptions of the classrooms. For example, female students were generally more positive about temperature and visibility and less positive about acoustics than male students. Zheng Yang et al. (2013) go on to argue that attempts to improve learning environments must recognize the importance of students subjective perceptions.

The idea that the learning environment might function on a symbolic level is not new (Proshansky and Wolfe, 1974) and researchers such as Weinstein and Woolfolk (1981) have argued that the physical design of learning spaces can be seen as a source of information that influence student expectations and that research should explore this in more detail by looking at how students' inferences about environmental characteristics relate to measures of student educational outcomes and

experiences. For example, Sommer (1977) explains how the physical arrangement of classroom furniture combined with real and symbolic barriers, indicate to students the level of classroom interaction that is preferred.

In a similar vein, Maxwell (2007) demonstrated that learning spaces that support the development of competence in children are likely to enhance self-esteem, and that demonstrating a link between the learning environment and self-esteem may be an important step in explaining how the physical learning environment may relate to academic achievement. For example, self-esteem may impact on student motivation which in turn impacts on academic achievement (Maxwell, 2007). In this respect, student characteristics such as motivation may be seen as a mediator in the relationship between the physical learning environment and academic achievement. A study on new secondary school buildings in Scotland found that these new schools were associated with higher ratings of security from students (Edgerton et al., n.d.). Within the context of the Scottish education system, this finding is significant as the national curriculum in Scotland emphasizes the importance of schools promoting an atmosphere of safety and security for young people (The Scottish Government, 2008). With respect to the relationship between the learning environment and academic achievement, feelings of safety and security might be seen as a potential mediator variable, i.e., if students feel safe and secure in their school, they may be more likely to focus on learning activities associated with academic achievement.

A number of researchers have also recognized that students are able to "read" the physical environment of their school and how this relates to them, and that the physical learning can communicate the school or even society's values to students (Maxwell, 2003; Fine et al., 2004). For example, if the learning environment communicates that children are a low priority, e.g., through poor maintenance or outdated facilities, the message is negative.

The preceding review suggests that the physical learning environment can be an important source of information for students and the way in which this is perceived can relate to characteristics such as student motivation and engagement which in turn may be related to academic achievement. From a theoretical perspective the bioecological model proposes that learning and psychological functioning are influenced by multiple, nested layers of the context of the individual (Bronfenbrenner and Morris, 2006) however, one neglected aspect of this model is the built environment (Evans, 2003). The relationship between the physical learning environment, psychological states (such as motivation), individual perceptions of the environment and academic achievement, has received less attention in the empirical literature and particularly within recent times.

In addition to understanding students' subjective perceptions of their learning environment, research has also shown the importance of understanding students' subjective perceptions of their own behavior within school. For example, in relation to educational outcomes, Edgerton et al. (2011) found that secondary school students with more positive perceptions of their school environment were more likely to perceive themselves as engaging more with school (e.g., volunteering within class) and having higher levels of self-esteem. Likewise, Midgely (2002) measured students' perceptions of their motivational orientation through the development of the Patterns of Adaptive Learning Scales (PALS) that assessed students' subjective perceptions of their personal achievement goals and their perceptions of the goal structure in the classroom. Research using this measure with students has shown how perceptions of learning goals may be associated with subjective perceptions of wellbeing and that this might be influenced by cultural factors (Tian et al., 2017).

This paper addresses the above limitations by using a subjective measure of students' perceptions of their "whole" school environment and explored how this is related to academic achievement using national, standardized measures of academic achievement. In addition, we included measures of relevant educational outcomes and experiences, and secondary data on other variables that research has consistently shown to be important predictors of academic achievement (i.e., SES, attendance and gender).

The primary aim of this study was to understand if students' subjective perceptions of their school environment were related to academic achievement alongside previously identified variables. The secondary aim was to investigate whether any relationship between students' perceptions of their school environment and academic achievement is mediated by other potential factors. The hypotheses for the study are therefore:

> *H1*: Students' subjective perceptions of their physical school environment will be significantly related to academic achievement along with SES, attendance and gender.
>
> *H2*: The relationship between students' subjective perceptions of their physical school environment and academic achievement will be mediated by student perceptions of their engaging behavior, environmental difficulty, security, and motivation.

2. Methodology

2.1. Background

The data for this study was collected as part of larger-scale study evaluating a secondary school building program with a Local Authority in Central Scotland. In Scotland such schools accommodate students between 12 and 17 years of age. While the larger scale study collected data at different points in the construction process, for the purposes of this paper, we will only look at the data that was collected 46 months after the new schools had opened (May 2013). By adopting this approach, we focus only on those students that have had the most time in the new school environments without any of the inconvenience of the construction process.

2.2. Design

This study employed a correlational design using data that was collected using a specifically developed questionnaire to measure students' perceptions of their school environment along with important education-related variables and their "in-school behaviour." For the purposes of this study, the following data from the questionnaire was used.

2.3. Measures

2.3.1. The physical school environment

Firstly, a measure of students' perceptions of their physical school environment was created based on information obtained from a series of focus groups conducted with students in two of the schools involved in the school re-building program (for further details see McEwen et al.,

2011). This section consisted of 60 items that covered different areas of the school, such as classrooms, social spaces, circulation spaces and toilet facilities, and were answered on a five-point Likert scale from "very poor" through to "very good." The items showed good internal reliability (Cronbach's alpha = 0.971) For the purpose of this study, we produced a student "global environmental perception" score (GEP) by summing the average score across these items. A copy of the 60 items can be found in Appendix 1.

2.3.2. "In-school behaviours"

Secondly, a measure of important "in-school behaviours" was created and again this was based on information obtained from the series of focus groups. Three categories of behavior were identified, and students were asked to rate how often they performed a range of behaviors on a four point scale ranging from "never" through to "always." The three categories of "in-school behaviour" were: Engaging Behavior (9 items), Environmental Difficulty (7 items), and Security (5 items). All of these sub-scales had acceptable levels of reliability as indicated by the following Cronbach's alpha coefficients: Engaging Behavior (0.712), Environmental Difficulty (0.652), and Security (0.653). A copy of the "in-school behaviour" items can be found in Appendix 2.

2.3.3. Achievement goal orientations

Thirdly, student motivation was measured using Midgely et al. (2000), Patterns of Adaptive Learning Scale (PALS). This measures the achievement goal orientations of students in relation to school achievement, i.e., how they approach, engage and evaluate their learning within an achievement context. PALS assesses three different learning goals: (i) Mastery Approach—this is considered a beneficial approach to learning where students desire to master the task at hand, (ii) Performance Approach—although there is some debate about whether this is a positive or negative approach to learning, it is generally considered to be a beneficial approach where students attempt to show that they can perform as well as or better than their peers, and (iii) Performance Avoidance—this is considered a maladaptive approach to learning where students avoid participating in class to avoid failing. As expected, there was good reliability for this standardized instrument, with the following Cronbach's alphas: Mastery Approach (0.854), Performance Approach (0.846), and Performance Avoidance (0.696).

2.3.4. Secondary data (gender, SES, and academic achievement)

Finally, in addition to the questionnaire data, the Local Authority provided the research team with secondary data for each student for the following variables: Gender; SES (based on postcode address—in Scotland these are ranked in SIMD deciles where 1 = highest level of deprivation and 10 = lowest level of deprivation); and Attendance level (ranging from 0 to 100%). Academic achievement was calculated based on validated data by the Scottish Qualifications Authority (SQA); this is the executive, non-departmental public body of the Scottish Government responsible for accrediting national educational awards. At S5 level, all courses have externally marked exams and students are awarded a band between 1 and 7 for each subject (with 1 being the highest band). To calculate a global score for students' academic performance, the bands achieved for each course were multiplied by the appropriate value to reflect the level of difficulty as indicated by the SQA Credit Qualification Framework.

2.4. Participants

The study collected data from S5 students (approximately 16 years of age) in five schools. Once permission for the study was obtained from the Local Authority and ethical approval was granted by the University ethics committee, the questionnaires were administered in each school in either the assembly hall with all students from the year group present or in individual registration classes. In both cases, researchers were present during the data collection to distribute and collect the questionnaires and answer any questions that students might have.

If participants had missing data on any of the variables, they were excluded from the relevant analyses (in total, 18 participants eliminated, mostly due to lack of SIMD data). In total, across all schools, 441 students completed the questionnaire; this constitutes a response rate of 63.3%. Of these, 229 were male (51.9%) and 212 were female (49.1%).

2.5. Data analysis

Pearson correlational analyses were conducted to assess the relationship between the study variables. Multiple regression analysis was conducted to test the first hypothesis that GEP will be significantly related to academic achievement along with SES, attendance and gender. A hierarchical multiple regression analysis was then conducted to test the second hypothesis that the relationship between GEP and academic achievement will be mediated by student perceptions of their engaging behavior, environmental difficulty, security, and motivation.

3. Results

Table 1 displays the descriptive statistics for the main variables (with the exception of gender, which was explained in the methodology). GEP was normally distributed and higher scores indicate more positive perceptions of the physical school environment. Academic achievement and SES were slightly negatively skewed and since higher levels of SES indicate less deprivation, this group of students as a whole were from relatively affluent backgrounds. Attendance ranged from 1 to 100% and was heavily negatively skewed so a logit transformation was computed for subsequent analyses.

Academic achievement scores were related to GEP, attendance, SES and gender (Table 2). There were moderate positive correlations between academic achievement and both attendance and SES and smaller positive correlations with GEP and gender (females scoring more highly than males). SES and attendance were also positively correlated but there were no other significant correlations. In particular GEP was not related to attendance, gender or SES.

TABLE 1 Descriptive statistics for hypothesis one, study variables.

	Range	Mean±Sd	Skewness±SE
Global Environmental Perception (GEP)	123–278	204.34 ± 24.83	0.01 ± 0.12
Academic achievement	0–420	230.29 ± 96.51	−0.30 ± 0.12
SES	1–10	7.25 ± 2.91	−0.71 ± 0.12
Attendance	0.01–1	0.95 ± 0.07	−7.54 ± 0.12

TABLE 2 Correlations between study variables.

	Academic achievement	GEP	Attendance	SES
GEP	0.16*			
Attendance	0.29*	0.01		
SES	0.31*	0.03	0.14*	
Gender†	0.12**	0.04	−0.08	0.04

*$p < 0.01$, **$p < 0.05$.
†Point biserial correlation.

A multiple regression was run to predict academic achievement from GEP, attendance, SES and gender. The multiple regression model significantly predicted academic achievement, $F(4, 436) = 27.0$, $p < 0.001$, adj. $R^2 = 0.21$. All four variables added statistically significantly to the prediction, $p < 0.01$. Regression coefficients and standard errors can be found in Table 3.

Standardized beta values showed that attendance and SES were of similar importance with gender and GEP less important. However, it does indicate the GEP is a significant predictor of academic achievement and this supports the first hypothesis.

To test the second hypothesis, we conducted a further regression analysis that included potential mediating factors between GEP and academic achievement. These were the three categories of "in-school behaviours": engaging behavior, environmental difficulty and security, and three learning goals (mastery approach, performance approach, and performance avoidance).

Table 4 gives the descriptive statistics for these variables. Engaging Behavior, Environmental Difficulty, Performance Approach, and Performance Avoidance were all normally distributed. Security was positively skewed and a transformation using the natural log was computed for subsequent analyses. Mastery approach was negatively skewed and so a transformation was computed for subsequent analyses.

Table 5 shows the partial correlations between GEP, "in-school behaviours" and learning goals controlling for attendance, SES and gender. GEP was positively correlated with engaging behaviors and mastery approach but was negatively related to environmental difficulty and security. Engaging behavior was strongly related to mastery approach and environmental difficulty was strongly related to security.

A hierarchical regression analysis on academic achievement with attendance, SES and gender entered as predictors in the first block and GEP, engaging behavior, environmental difficulty, security, mastery approach, performance approach and performance avoidance entered stepwise in the second block was significant [$F(5, 434) = 30.0$, $p < 0.01$, adj. $R^2 = 0.25$]. The adjusted R^2 was 0.17 for the first block and 0.25 after the second block; the change of 0.08 was significant ($p < 0.01$).

There were five significant predictors, attendance, SES, gender, engaging behavior and environmental difficulty (Table 6, $p < 0.01$). Standardized beta values showed that attendance, SES and engaging behavior were of similar importance with gender and environmental difficulty less important. The model as a whole was a better fit than the earlier model with an adjusted R^2 of 0.25.

Figure 1 shows the partial correlations between academic achievement, GEP, engaging behavior and environmental difficulty once attendance, SES and gender are controlled for. This indicates that while the direct correlation between academic achievement and GEP is modest, GEP is strongly related to both engaging behavior (positively) and environmental difficulty (negatively) which are both in turn related to academic achievement.

TABLE 3 Regression statistics for model with four predictor variables and academic achievement as outcome variable.

Academic achievement	*B*	95% CI for *B*	β	ΔR^2	
Model					0.21*
Constant	−30.80				
Attendance	20.68*	13.89	27.51	0.26*	
SES	9.17*	6.35	11.99	0.28*	
Gender	28.00*	11.67	44.39	0.15*	
GEP	0.55*	0.22	0.88	0.14*	

B, unstandardized regression coefficient; CI, confidence interval; β, standardized coefficient. ΔR^2, adjusted R^2. *$p < 0.01$.

TABLE 4 Descriptive statistics for hypothesis two, study variables.

	Range	Mean±Sd	Skewness±SE
Engaging behavior	12–35	24.00 ± 3.86	0.01 ± 0.12
Environmental difficulty	7–23	13.62 ± 2.79	0.54 ± 0.12
Security	5–17	7.75 ± 2.02	1.00 ± 0.12
Mastery approach	10–25	21.37 ± 3.16	−0.94 ± 0.17
Performance approach	5–25	13.00 ± 4.62	0.31 ± 0.17
Performance avoidance	4–20	11.46 ± 3.76	0.03 ± 0.17

These results partially support Hypothesis 2 and indicate that the relationship between GEP and academic achievement is mediated by engaging behavior and environmental difficulty.

4. Discussion

The results support previous research that has highlighted that gender, SES, and attendance are significantly related with academic achievement. However, the results also make an important additional contribution by indicating that students' perceptions of their physical school environment may also be important in explaining the variance in academic achievement. This finding suggests that the importance of the physical environment may depend on students' perceptions of that environment (Vosko, 1984) and as such, should be treated as important factors to consider in attempts to improve learning environments (Siegel, 2003).

While the resulting model only explained 21% of the variance in academic achievement, it is worth noting that the model did not include a measure of IQ or general intelligence. Previous research has shown that measures of general intelligence are good predictors of academic achievement, with correlations between 0.5 and 0.8 (Deary et al., 2007; Rohde and Thompson, 2007) and psychometric measures of intelligence have been shown to account for about 30% of the variance of academic achievement, depending on level of education (Gustafsson and Balke, 1993; Roth et al., 2015). At the same time, these studies also highlight that a large part of the variance in academic achievement is not accounted for by measures of general intelligence and that for some students, there is a discrepancy between their actual and expected level of academic performance, given IQ is known; this is known as the "IQ-achievement gap" (Flynn, 1991). While this study measures academic achievement rather than general intelligence, it

TABLE 5 Partial correlations between study variables.

	GEP	Engaging behavior	Environmental difficulty	Security	Mastery approach	Performance approach
Engaging behavior	0.305*					
Environmental difficulty	−0.403*	−0.039				
Security	−0.337*	−0.138*	0.302*			
Mastery approach	0.174*	0.349*	0.090	−0.001		
Performance approach	−0.052	0.104**	0.094	0.044	0.189*	
Performance avoidance	−0.085	0.067	0.099**	0.062	0.200*	0.738*

*$p < 0.01$; **$p < 0.05$ attendance, SES and gender controlled.

TABLE 6 Regression statistics for model with five predictor variables and academic achievement as outcome variable.

Academic achievement	*B*	95% CI for *B*		β	ΔR^2
Model					0.25*
Constant	−7.55				
Attendance	16.82*	10.12	23.51	0.21*	
SES	8.35*	5.61	11.09	0.25*	
Gender	22.16*	6.02	38.30	0.12*	
Engaging behavior	6.37*	4.25	8.48	0.25*	
Environmental Difficulty	−4.21*	−7.05	−1.37	−0.12*	

B, unstandardized regression coefficient; CI, confidence interval; β, standardized coefficient. *$p < 0.01$; ΔR^2, adjusted R^2.

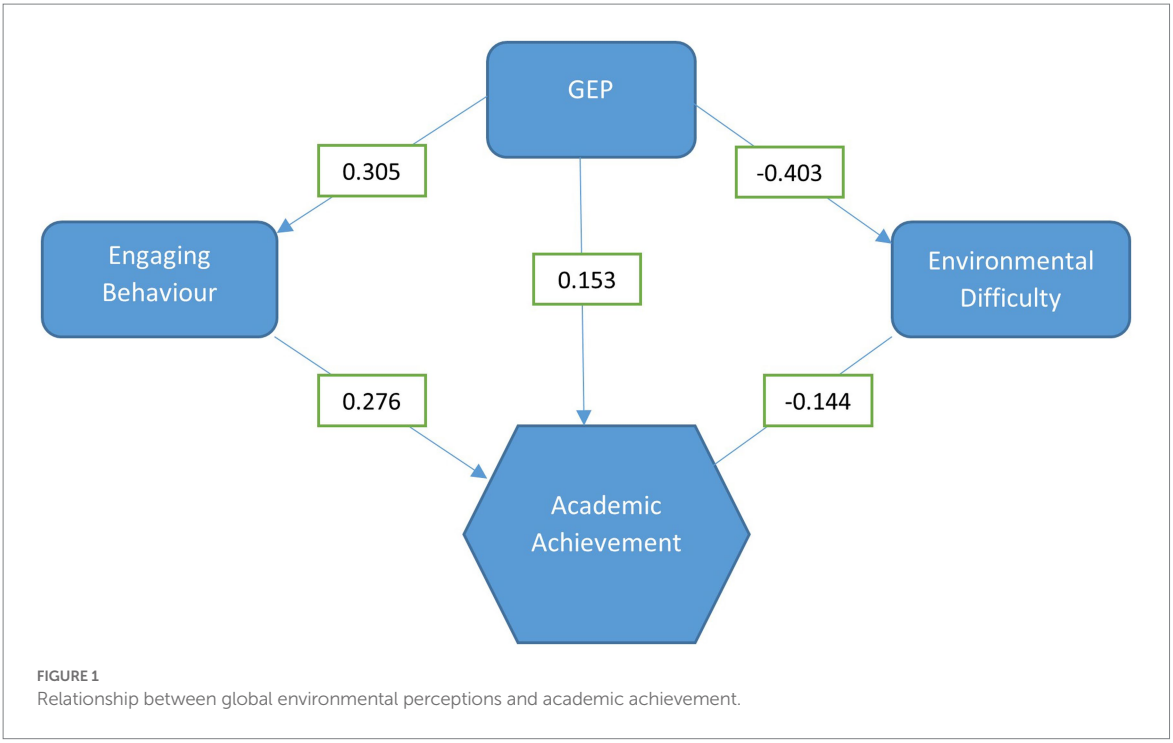

FIGURE 1
Relationship between global environmental perceptions and academic achievement.

suggests that in addition to school attendance, SES and gender, students' perceptions of their physical school environment may explain some of the discrepancy between actual and expected level of academic achievement.

In relation to the second aim of the study, the results offer partial support for the hypothesis as they show that the relationship between students' perceptions of their physical learning environment and academic achievement may be mediated by certain "in-school behaviours" but not by learning goals. This suggests an indirect relationship between students' perceptions of their physical learning environment and academic achievement with these perceptions being mediated *via* engaging behavior and environmental difficulty, i.e., more positive perceptions of the physical school environment are associated with more engaging behavior and less environmental difficulty, which

in turn is associated with greater academic achievement. To better understand these results, it is useful to look in more detail at the concepts of engaging behavior and environmental difficulty as measured in this study.

Engaging behavior was assessed by asking students to indicate how often they performed behaviors such as using the library outside of class times, attending after school clubs or sports activities, volunteering for things when asked, helping other students in class with their work, and answering teachers' questions in the classroom. We would argue that if students have more positive perceptions of their physical school environment then this symbolically indicates to students that their education is valued by important stakeholders in the education system in terms of investment, maintenance, etc. This is supported by the work of Weinstein and Woolfolk (1981) that highlights the potential symbolic effects of the physical environment. In addition, it is also likely that where students have more positive perceptions of spaces in their school environment such as classrooms and library and sports facilities, they are much more likely to perform "engaging behaviour" that relate to these spaces. This view could be interpreted using "person-environment fit theory" that has been developed in workplace studies; here "fit" is defined in terms of the comparison of person and environment characteristics to determine whether or not there is a match (Kristof-Brown and Billsberry, 2013). An important concept within this theory is that the fit between the person and the environment can be objective or subjective and subjective fit is based on the perception of the individual (Van Vianen, 2018). It is highly likely that greater levels of engaging behavior such as answering teachers' questions in class, helping other students with their work and more use of library facilities could have a positive, direct impact on academic achievement as these are activities that support learning. However, it is also possible that greater levels of engaging behavior are associated with greater enjoyment or liking of school which in turn has been shown to relate to academic achievement (Ladd et al., 2000; Riglin et al., 2013) and a more positive school climate which is positively related to prerequisites for learning such as student engagement and attitudes toward school (Wang and Holcombe, 2010; Van Ryzin, 2011).

Environmental Difficulty was assessed by asking students to indicate the frequency with which they found it difficult to move around between classes because of the layout of the school, got confused with the layout of the school, and found different areas of the school too busy (corridors, toilets, social spaces, etc.). Here again, we can use "person-environment fit theory" to explain this finding as more positive perceptions of the physical school environment are likely to be associated with less subjective perceptions of environmental difficulty, i.e., students abilities and needs (person) have a better fit with physical characteristics of the school such as amount of space and legibility (environment). Using person-environment fit theory, we would argue that where students experience less difficulty interacting with their school environment, this facilitates activities that have positive consequences, e.g., being able to get to class on time without stress or difficulty puts the student in a frame of mind conducive to learning. Similarly, being able to find spaces that support peer interaction facilitates "positive" outcomes associated with informal learning and the importance of informal learning spaces has been demonstrated in other learning contexts (Acker and Miller, 2005).

Although the findings are promising, our study also has several limitations. First, the study was limited to one year group of students and we should be cautious in accepting the generalizability of our findings to other year groups of students. As Maxwell (2000) highlights, between group differences are important factors to consider when investigating users perceptions of their physical environment. A second limitation relates to our interpretation of causal relationships between GEP and academic achievement, i.e., it is possible that students who are doing well may perceive their school more positively and therefore, higher levels of academic achievement may lead to more positive environmental perceptions. A final limitation is that we used a global environmental perception measure that was based on a summative total of different areas of the school environment. However, it may be that different areas and spaces within the school environment might vary in importance to students and as such future, research might consider disaggregating the whole school environment into smaller units such as classrooms, circulation spaces and social spaces to examine the relative contribution of different areas of the school environment to students' academic achievement. Adopting this approach might provide practical information of interest to stakeholders such as estate managers, design professionals and educational practitioners.

To summarize therefore, this study has demonstrated that students' subjective perceptions of their physical school environment are related to academic achievement. In addition, this relationship is likely to be indirect with students' subjective perceptions of their physical school environment being strongly associated with greater engaging behavior and less environmental difficulty which in turn is related to academic achievement.

These findings may have important implications for a range of stakeholders involved with school estates. Attempts to improve learning environments should recognize the value of understanding students' subjective perceptions of their physical learning environments in addition to objective measures of important environmental characteristics; this includes symbolic aspects such as the message that the learning environment may be communicating to students. In addition, it is important to understand what aspects of their learning environment students perceive as being more important to them and how this might be influenced by individual differences between different groups of students such as age and gender.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by University of the West of Scotland, School of Social Sciences, Ethics Committee. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

EE and JM were responsible for the design of the study, the implementation of the study along with data analyses and

dissemination. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.959259/full#supplementary-material

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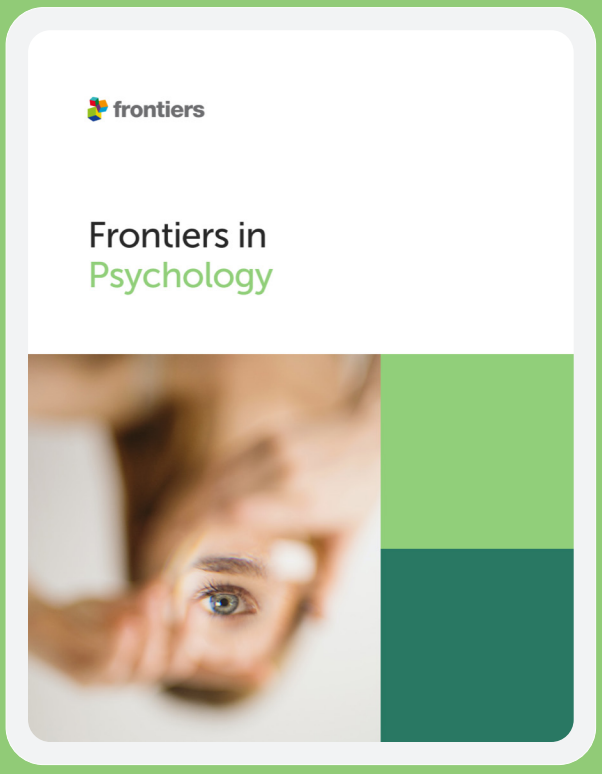

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