

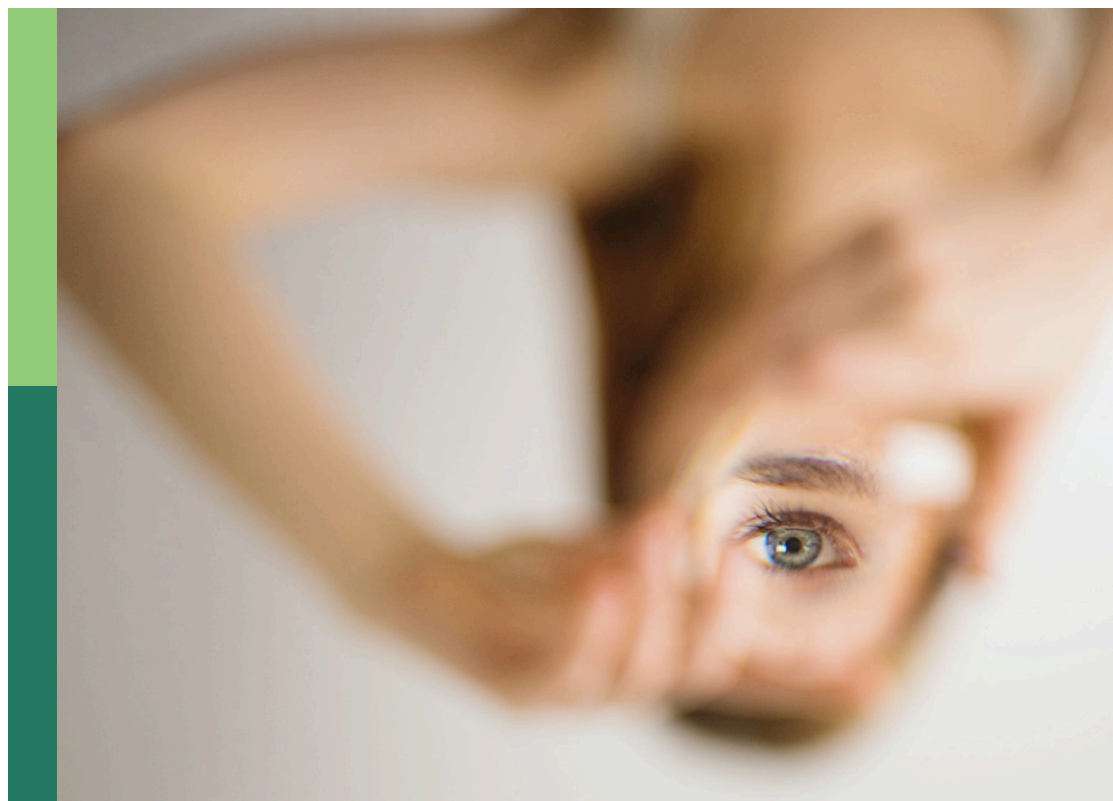
How do behavior science interventions to reduce environmental impacts work in the real world?

Edited by

Christian Andreas Klöckner, Jens Røyrvik, Giuseppe Carrus
and Michael Niederkofler

Published in

Frontiers in Psychology



FRONTIERS EBOOK COPYRIGHT STATEMENT

The copyright in the text of individual articles in this ebook is the property of their respective authors or their respective institutions or funders. The copyright in graphics and images within each article may be subject to copyright of other parties. In both cases this is subject to a license granted to Frontiers.

The compilation of articles constituting this ebook is the property of Frontiers.

Each article within this ebook, and the ebook itself, are published under the most recent version of the Creative Commons CC-BY licence. The version current at the date of publication of this ebook is CC-BY 4.0. If the CC-BY licence is updated, the licence granted by Frontiers is automatically updated to the new version.

When exercising any right under the CC-BY licence, Frontiers must be attributed as the original publisher of the article or ebook, as applicable.

Authors have the responsibility of ensuring that any graphics or other materials which are the property of others may be included in the CC-BY licence, but this should be checked before relying on the CC-BY licence to reproduce those materials. Any copyright notices relating to those materials must be complied with.

Copyright and source acknowledgement notices may not be removed and must be displayed in any copy, derivative work or partial copy which includes the elements in question.

All copyright, and all rights therein, are protected by national and international copyright laws. The above represents a summary only. For further information please read Frontiers' Conditions for Website Use and Copyright Statement, and the applicable CC-BY licence.

ISSN 1664-8714
ISBN 978-2-8325-7151-4
DOI 10.3389/978-2-8325-7151-4

Generative AI statement

Any alternative text (Alt text) provided alongside figures in the articles in this ebook has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

About Frontiers

Frontiers is more than just an open access publisher of scholarly articles: it is a pioneering approach to the world of academia, radically improving the way scholarly research is managed. The grand vision of Frontiers is a world where all people have an equal opportunity to seek, share and generate knowledge. Frontiers provides immediate and permanent online open access to all its publications, but this alone is not enough to realize our grand goals.

Frontiers journal series

The Frontiers journal series is a multi-tier and interdisciplinary set of open-access, online journals, promising a paradigm shift from the current review, selection and dissemination processes in academic publishing. All Frontiers journals are driven by researchers for researchers; therefore, they constitute a service to the scholarly community. At the same time, the *Frontiers journal series* operates on a revolutionary invention, the tiered publishing system, initially addressing specific communities of scholars, and gradually climbing up to broader public understanding, thus serving the interests of the lay society, too.

Dedication to quality

Each Frontiers article is a landmark of the highest quality, thanks to genuinely collaborative interactions between authors and review editors, who include some of the world's best academicians. Research must be certified by peers before entering a stream of knowledge that may eventually reach the public - and shape society; therefore, Frontiers only applies the most rigorous and unbiased reviews. Frontiers revolutionizes research publishing by freely delivering the most outstanding research, evaluated with no bias from both the academic and social point of view. By applying the most advanced information technologies, Frontiers is catapulting scholarly publishing into a new generation.

What are Frontiers Research Topics?

Frontiers Research Topics are very popular trademarks of the *Frontiers journals series*: they are collections of at least ten articles, all centered on a particular subject. With their unique mix of varied contributions from Original Research to Review Articles, Frontiers Research Topics unify the most influential researchers, the latest key findings and historical advances in a hot research area.

Find out more on how to host your own Frontiers Research Topic or contribute to one as an author by contacting the Frontiers editorial office: frontiersin.org/about/contact

How do behavior science interventions to reduce environmental impacts work in the real world?

Topic editors

Christian Andreas Klöckner — Norwegian University of Science and Technology, Norway

Jens Røyrvik — NTNU Social Research, Norway

Giuseppe Carrus — Roma Tre University, Italy

Michael Niederkofler — Innovation Lab act4.energy, Austria

Citation

Klöckner, C. A., Røyrvik, J., Carrus, G., Niederkofler, M., eds. (2025). *How do behavior science interventions to reduce environmental impacts work in the real world?* Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-7151-4

Table of contents

- 05 **Editorial: How do behavior science interventions to reduce environmental impacts work in the real world?**
Christian Andreas Klöckner, Giuseppe Carrus, Jens Rørvik and Michael Niederkofler
- 08 **Digital technologies for behavioral change in sustainability domains: a systematic mapping review**
Oriana Mosca, Andrea Manunza, Sara Manca, Giuliano Vivanet and Ferdinando Fornara
- 38 **“Eco-caring together” pro-ecological group-based community interventions and mental wellbeing: a systematic scoping review**
Kane Baker, Bianca Chioran and Elizabeth Marks
- 60 **Effectiveness and context dependency of social norm interventions: five field experiments on nudging pro-environmental and pro-social behavior**
Daria Mundt, Marlene C. L. Batzke, Thanee M. Bläsing, Sandro Gomera Deaño and Anna Helfers
- 73 **Using an Instagram campaign to influence knowledge, subjective norms, perceived behavioral control, and behavioral intentions for sustainable behaviors**
Alexander Varni, Chan L. Thai and Sandra Jamaledine
- 85 **Understanding users of online energy efficiency counseling: comparison to representative samples in Norway**
Christian A. Klöckner, Alim Nayum and Stepan Vesely
- 99 **Exploring the emotional mechanism of consumer satisfaction in new energy vehicles: a dual-path model of intelligent and eco-friendly experiences**
Shizhen Bai, Tao Sun and Hao He
- 112 **Why should I when no one else does? A review of social norm appeals to promote sustainable minority behavior**
Anna Schorn
- 133 **Applying a new theoretical and methodological approach for behavior-change campaign planning: identifying the critical determinants for reducing littering and evaluating the resulting large-scale campaign**
Robert Tobias, Nicole Moraz and Barbara Degenhardt
- 151 **Psychological barriers in children: an exploratory study on Dengue transmission using an adapted DIPB scale**
Pedro Schimmelpfeng, Luiz Gonzaga Lapa and Claudia Marcia Lyra Pato
- 163 **Morally “loaded” labels in the built environment influence perceptions and social judgments**
Andreas Haga

- 170 **The role of information and participation in overcoming users' initial reluctance: a case study of a decentralized wastewater treatment plant**
Sergio Vila-Tojo, Cristina Gómez-Román and Jose-Manuel Sabucedo
- 181 **Encouraging water-saving behavior during a "Moment of Change": the efficacy of implementation intentions on water conservation during the transition to university**
Kaloyan Mitev, Freya Rennison, Paul Haggar, Rebecca Hafner, Alice Lowe and Lorraine Whitmarsh
- 195 **From concept to impact: strategic guidelines for environmental behavior change interventions**
Mehmet Efe Biresselioglu and Muhittin Hakan Demir
- 209 **Expanding the green gaming horizon: a conceptual analysis of and proposed guidelines for upscaling environmental game usage in climate education**
Kristoffer Skomsøy Fjællingsdal
- 218 **Efficacy of personalized feedback in encouraging sustainable washing behavior: evidence from a pilot study in Germany**
Laura Höpfl, Ivan Đula, Francisco Kiss, Rebecca Walter and Maria Wirzberger
- 229 **Social environment, low-carbon cognition and low-carbon consumption behaviors of youth groups: evidence from Xizang, China**
Huifang Ma and Qin Chen
- 239 **Workplace sustainability: energy-saving behaviors in office environments of Thailand**
Su Wutyi Hnin, Amna Javed, Jessada Karnjana, Chawalit Jeenanunta and Youji Kohda
- 252 **Reducing meat consumption through default nudging: a field study**
Tamar F. Ardesch, Sandra Klaperski-van der Wal, Sari R. R. Nijssen and Barbara C. N. Müller
- 262 **Behavior change interventions to promote adoption of e-bike shared mobility in a rural area: evidence from a mixed-method field trial**
Mark Wilson and Lorraine Whitmarsh



OPEN ACCESS

EDITED AND REVIEWED BY
Francesco Aletta,
University College London, United Kingdom

*CORRESPONDENCE
Christian Andreas Klöckner
✉ Christian.klockner@ntnu.no

RECEIVED 01 September 2025
ACCEPTED 15 October 2025
PUBLISHED 03 November 2025

CITATION
Klöckner CA, Carrus G, Røyrvik J and
Niederkofer M (2025) Editorial: How do
behavior science interventions to reduce
environmental impacts work in the real world?
Front. Psychol. 16:1696849.
doi: 10.3389/fpsyg.2025.1696849

COPYRIGHT
© 2025 Klöckner, Carrus, Røyrvik and
Niederkofer. This is an open-access article
distributed under the terms of the [Creative
Commons Attribution License \(CC BY\)](#). The
use, distribution or reproduction in other
forums is permitted, provided the original
author(s) and the copyright owner(s) are
credited and that the original publication in
this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Editorial: How do behavior science interventions to reduce environmental impacts work in the real world?

Christian Andreas Klöckner^{1*}, Giuseppe Carrus², Jens Røyrvik³
and Michael Niederkofer⁴

¹Department of Psychology, Norwegian University of Science and Technology, Trondheim, Norway, ²Department of Educational Science, University Roma Tre, Rome, Italy, ³Department of Anthropology, Norwegian University of Science and Technology, Trondheim, Norway, ⁴Innovation Lab act4energy, Stegersbach, Austria

KEYWORDS

behavior science, intervention—behavioral, real world, psychology, environmental behavior

Editorial on the Research Topic

How do behavior science interventions to reduce environmental impacts work in the real world?

1 Introduction

Environmental psychology and related behavior sciences have made substantial progress in theory development and in studying interventions to change people's pro-environmental behavior, as demonstrated by numerous meta-analyses published over the past decades (e.g., Bamberg and Möser, 2007; Klöckner, 2013; Maki et al., 2019; Udall et al., 2021; Osbaldiston and Schott, 2012). However, environmental psychologists have also been encouraged to place greater emphasis on the potential impact of the behaviors they aim to change and to invest more effort into developing and testing interventions targeting such high-impact behaviors (e.g., Nielsen et al., 2021; Gatersleben, 2023), while at the same time not ignoring the role of smaller or symbolic actions in signaling changing social norms and building momentum for broader change. Furthermore, although environmental psychology thrives as a discipline, the strong dominance of studies conducted in Western cultures is increasingly criticized within psychology in general, including in environmental psychology (e.g., Gould et al., 2025; Masuda et al., 2020). Montesanti et al. (2021) provide a good example of how incorporating indigenous perspectives on coping with environmental stress can enrich theory building and practices of dealing with real-world issues (wildfires, in this case). Finally, several researchers have repeatedly called for a stronger focus of environmental psychology on the usability of its research for practical implementation (e.g., Ernst and Wenzel, 2014; Clayton et al., 2016). We wholeheartedly support these calls for a behavior science that makes a real difference by focusing on behaviors with the potential to change impact substantially, extending beyond the WEIRD populations and providing clear recommendations to practitioners. Combining the last two points,

recommendations to practitioners beyond the Western world remain largely neglected in environmental psychology. In our view, this also requires a focus on articles studying the effects of psychological interventions in the real world. Taking this as a starting point, we launched our call for a Research Topic in 2024 with exactly this focus, the outcomes of which are presented here.

2 Focusing on impact in the real world

To be able to make a change in the real world, behavior science needs to study behaviors that have the potential to make a difference, when changed, either because they have a high environmental impact, are practiced by many people, or can stimulate broader changes by establishing new social norms, even if their individual impact is small. Furthermore, behavior change interventions for such behaviors need to be tested under real-world conditions. Within this Research Topic, you will find empirical research that does both: studying relevant behaviors within the complexities of real-world contexts. For example, [Wilson and Whitmarsh](#) focus on one of the most impactful categories of individual behavior—mobility—specifically examining shared e-bike use in rural areas. In addition, [Bai et al.](#) focus on mobility through their study on the role of emotions in shaping consumer satisfaction among users of alternative fuel vehicles. [Ardesch et al.](#) address another high-impact behavior in their intervention study on reducing meat consumption in cafeterias. [Klößner et al.](#) examine how one-stop webshops providing energy counseling and assistance to homeowners increase their ambition for energy renovation projects, potentially unlocking substantial energy savings. [Hinn et al.](#) look at energy use in office buildings and explore the psychological context of energy saving. [Höpfel et al.](#) investigate different intervention framing approaches to change people's use of washing machines to reduce energy and water consumption. Furthermore, [Mitev et al.](#) focus on reducing water consumption in their intervention study with university freshmen, exploring the potential of windows of opportunities when people change their life situation. A related topic is addressed by [Vila-Tojo et al.](#), who examine how resistance to decentralized wastewater treatment can be reduced through information and participatory approaches. [Tobias et al.](#) use a theoretically well-grounded approach to design and evaluate an anti-littering campaign in public parks in Switzerland. Finally, [Schimmelpfeng et al.](#) address a topic related to the effects of environmental change, namely dengue fever and prophylactic treatment of children. Using the psychological framework of the dragons of inaction ([Gifford, 2011](#)), they examine the drivers of dengue transmission in Brazil.

3 Going beyond the Western world

The articles in our Research Topic cover a diverse range of countries, such as Norway, the USA, Germany, the UK, the Netherlands, Thailand, China, Spain, Sweden, Brazil, and Switzerland, as well as an international database of car information and discussion platforms. Although the majority

of the presented articles are still based on data from Western, mostly European, populations, we would like to highlight the articles by [Hinn et al.](#), [Ma and Chen](#), and [Schimmelpfeng et al.](#) as important contributions that extend the global understanding of behavior research for the environment. Especially, the study by [Ma and Chen](#) seems relevant for this aspect, as it explores the role of social influence on pro-environmental behavior within the Chinese context. [Schimmelpfeng et al.](#) apply a well-established psychological framework to test its applicability in a Brazilian context, focusing on school children and health behavior. However, we would also like to acknowledge that more studies outside the Global North need to be conducted in environmental psychology, especially with challenging established theoretical frameworks and their applicability in new contexts.

4 Providing implementation guidelines

A total of three of our articles are literature reviews, addressing questions relevant for both researchers and practitioners: In her article, [Schorn](#) presents an interesting summary of findings from 54 studies on social influence on pro-environmental behavior, especially with a focus on how minorities might change the behavior of a majority group. This article provides helpful guidelines for how to design interventions for environmental activists. [Baker et al.](#) also address pro-environmental behavior from a social perspective in their review of the relationship between joint pro-environmental behavior and mental wellbeing, identifying particular potential in behaviors involving interaction with nature. The final review in our Research Topic by [Mosca et al.](#) addresses the interesting question of whether digital tools can enhance pro-environmental behavior. The authors come to the conclusion that this is still largely an under-researched issue, but they are able to give some recommendations. Closely related to this review article, [Fjællingsdal](#) proposes guidelines for how to design and scale up environmental game usage in practical applications. [Varni et al.](#) examine the design and success of a campaign based on social media, an approach that was also pursued by [Mundt et al.](#) and [Biresselioglu and Demir](#) present a very hands-on guideline for how to design and monitor the implementation of behavior science-informed interventions to promote pro-environmental behavior. [Haga](#) presents findings on how labeling a lamp as ecological changes the context in a positive way, specifically how people in pictures illuminated by this lamp are perceived more favorably. What is striking, however, is that these implementation guidelines strongly focus on interventions in the Global North; therefore, we need more studies and recommendations focusing specifically on environmental behaviors in the Global South.

5 Conclusion

This Research Topic of interesting articles shows how vivid environmental psychology and other behavior science research can be, addressing pressing problems of our societies. Looking at the articles, it is clear that such research can

help design interventions that really make a difference, but the reviews also show that further research is needed, especially research that extends beyond Europe and North America and, even more specifically, research on interventions and theory building from a non-Western perspective. We also believe that a closer collaboration between behavioral researchers and practitioners might improve the usability of this research further.

Author contributions

CK: Writing – original draft, Writing – review & editing. GC: Writing – original draft, Writing – review & editing. JR: Writing – review & editing, Writing – original draft. MN: Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This article received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957115, as part of the ENCHANT project (<http://www.enchant-project.eu>).

References

- Bamberg, S., and Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: a new meta-analysis of psycho-social determinants of pro-environmental behaviour. *J. Environ. Psychol.* 27, 14–25. doi: 10.1016/j.jenvp.2006.12.002
- Clayton, S., Devine-Wright, P., Swim, J., Bonnes, M., Steg, L., Whitmarsh, L., et al. (2016). Expanding the role for psychology in addressing environmental challenges. *Am. Psychol.* 71:199. doi: 10.1037/a0039482
- Ernst, A., and Wenzel, U. (2014). Bringing environmental psychology into action. *Eur. Psychol.* 19, 118–126. doi: 10.1027/1016-9040/a000174
- Gatersleben, B. (2023). “Measuring pro-environmental behaviour: a critical reflection,” in *Handbook on Pro-environmental Behaviour Change* eds, B. Gatersleben and N. Murtagh (Cheltenham: Edward Elgar Publishing), 114–124. doi: 10.4337/9781800882133.00015
- Gifford, R. (2011). The dragons of inaction: psychological barriers that limit climate change mitigation and adaptation. *Am. Psychol.* 66:290. doi: 10.1037/a0023566
- Gould, R. K., Naranjo, Y. J., and Balvanera, P. (2025). Relationality is not WEIRD: the importance of relational thinking in the majority of the planet's societies. *Ecosyst. People* 21:2427810. doi: 10.1080/26395916.2024.2427810
- Klößner, C. A. (2013). A comprehensive model of the psychology of environmental behaviour—a meta-analysis. *Glob. Environ. Change* 23, 1028–1038. doi: 10.1016/j.gloenvcha.2013.05.014
- Maki, A., Carrico, A. R., Raimi, K. T., Truelove, H. B., Araujo, B., and Yeung, K. L. (2019). Meta-analysis of pro-environmental behaviour spillover. *Nat. Sust.* 2, 307–315. doi: 10.1038/s41893-019-0263-9
- Masuda, T., Batdorj, B., and Senzaki, S. (2020). Culture and attention: future directions to expand research beyond the geographical regions of WEIRD cultures. *Front. Psychol.* 11:1394. doi: 10.3389/fpsyg.2020.01394
- Montesanti, S., Fitzpatrick, K., Azimi, T., McGee, T., Fayant, B., and Albert, L. (2021). Exploring Indigenous ways of coping after a wildfire disaster in Northern Alberta, Canada. *Qualit. Health Res.* 31, 1472–1485. doi: 10.1177/10497323211009194
- Nielsen, K. S., Cologna, V., Lange, F., Brick, C., and Stern, P. C. (2021). The case for impact-focused environmental psychology. *J. Environ. Psychol.* 74:101559. doi: 10.1016/j.jenvp.2021.101559
- Osbaldeston, R., and Schott, J. P. (2012). Environmental sustainability and behavioral science: meta-analysis of proenvironmental behavior experiments. *Environ. Behav.* 44, 257–299. doi: 10.1177/0013916511402673
- Udall, A. M., De Groot, J. I. M., De Jong, S. B., and Shankar, A. (2021). How I see me—A meta-analysis investigating the association between identities and pro-environmental behaviour. *Front. Psychol.* 12:582421. doi: 10.3389/fpsyg.2021.582421

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.

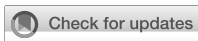
Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.



OPEN ACCESS

EDITED BY

Giuseppe Carrus,
Roma Tre University, Italy

REVIEWED BY

Siegfried Dewitte,
KU Leuven, Belgium
Nicola Rainisio,
University of Milan, Italy

*CORRESPONDENCE

Oriana Mosca
✉ oriana.mosca@unica.it

RECEIVED 04 June 2023

ACCEPTED 27 November 2023

PUBLISHED 03 January 2024

CITATION

Mosca O, Manunza A, Manca S, Vivanet G and
Fornara F (2024) Digital technologies for
behavioral change in sustainability domains: a
systematic mapping review.
Front. Psychol. 14:1234349.
doi: 10.3389/fpsyg.2023.1234349

COPYRIGHT

© 2024 Mosca, Manunza, Manca, Vivanet and
Fornara. This is an open-access article
distributed under the terms of the [Creative
Commons Attribution License \(CC BY\)](#). The
use, distribution or reproduction in other
forums is permitted, provided the original
author(s) and the copyright owner(s) are
credited and that the original publication in this
journal is cited, in accordance with accepted
academic practice. No use, distribution or
reproduction is permitted which does not
comply with these terms.

Digital technologies for behavioral change in sustainability domains: a systematic mapping review

Oriana Mosca*, Andrea Manunza, Sara Manca, Giuliano Vivanet
and Ferdinando Fornara

Department of Pedagogy, Psychology and Philosophy, University of Cagliari, Cagliari, Italy

Sustainability research has emerged as an interdisciplinary area of knowledge about how to achieve sustainable development, while political actions toward the goal are still in their infancy. A sustainable world is mirrored by a healthy environment in which humans can live without jeopardizing the survival of future generations. The main aim of this contribution was to carry out a systematic mapping (SM) of the applications of digital technologies in promoting environmental sustainability. From a rigorous search of different databases, a set of more than 1000 studies was initially retrieved and then, following screening criteria based on the ROSES (RepOrting standards for Systematic Evidence Syntheses) procedure, a total of $N = 37$ studies that met the eligibility criteria were selected. The studies were coded according to different descriptive variables, such as digital technology used for the intervention, type of sustainable behavior promoted, research design, and population for whom the intervention was applied. Results showed the emergence of three main clusters of Digital Technologies (i.e., virtual/immersive/augmented reality, gamification, and power-metering systems) and two main Sustainable Behaviors (SBs) (i.e., energy and water-saving, and pollution reduction). The need for a clearer knowledge of which digital interventions work and the reasons why they work (or do not work) does not emerge from the outcomes of this set of studies. Future studies on digital interventions should better detail intervention design characteristics, alongside the reasons underlying design choices, both behaviourally and technologically. This should increase the likelihood of the successful adoption of digital interventions promoting behavioral changes in a more sustainable direction.

KEYWORDS

systematic mapping, digital technologies, sustainable behaviors, gamification, power-metering

1 Introduction

Digitalization and sustainability (or sustainable development) are key issues for policy-makers and practitioners in the 21st century (Di Fabio, 2021). In this regard, since the use of digital technologies has become widespread, a full comprehension of their role in sustainable development is desirable. Recently, sustainability science has been characterized as an interdisciplinary research area (Rosen, 2017), from the natural to the applied sciences, moving from engineering to social sciences and humanities. This interdisciplinary approach allows a comprehensive understanding of the complex interplay between the planet we live on and human well-being, by taking into account the intertwined relationships among humans, the environment, and engineered systems (Di Fabio, 2021). Indeed, the knowledge about how to

reach sustainable development has grown, while policy development toward the goal is still in its infancy.

Research on sustainability is based on the concept of a balanced and harmonized life, at different levels, starting from the micro to the macro: individual, group and organizations and relationships among them, community, national, and trans-national levels (Di Fabio, 2021).

In 1987, the Brundtland Report, where the concept of sustainable development was first introduced, was published by the World Commission on Environment and Development (WCED), with a focus on possible answers to some critical threats and challenges which are still not solved nowadays, such as reaching an harmonization between economic development and environment protection, pollution reduction, the regulation of the exploitation of natural resources, harmful gas emissions, and climate impacts management, attainment of global peace, and hunger and poverty levels lowering. Sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 43), which became a widespread accepted and probably the most quoted definition in literature, commonly known as the “Brundtland definition”. Traditionally, sustainability is commonly described from a triple-bottom-line perspective, with a metaphor, that is the search for “balance” between three components, i.e., environment, economy, and society (the so-called “three-pillar model,” Hilty and Aebischer, 2015). Sustainability represents the act of balancing the pace of human development with the resources required to achieve such a goal. Indeed, in the XVIII century, Carl von Clausewitz stated that humans should not cut down trees at a rate faster than that at which they are replaced (Akande et al., 2019).

The economic area focuses on financial and economic outcomes, the social one is devoted to addressing inequalities and ensuring inclusion and accessibility of services and resources, while, the environmental area is related to protecting the environment from excessive pollution, like carbon emissions (Mensah, 2019).

Sustainability science has become closely interlaced with the spread of digitalization and more relevance has been put to digital technologies as instruments for improving global well-being (United Nations, 2015). Indeed, the UN has been working on an international agenda for sustainable development since 2016 and pointed at technology as an irreplaceable driver for reaching specific sustainable goals by 2030 (Camodeca and Almici, 2021). Sustainability and digitalization originated massive research about how these two fields of study, separately, changed the whole society (Camodeca and Almici, 2021). The intersection of these two domains, especially in the research of which digital intervention is the most effective to promote sustainability, however, remains a largely unexplored territory, with a few exceptions. For instance, Akande et al. (2019) focused on the role that Information and Communication Technology (ICT) has on carbon footprint decrease, which in turn fosters the sustainability of smart cities. In this study, ICT is an indicator of smartness, and CO₂ emissions are used as an indicator of sustainability in different European cities, thus underlining the need for a common strategy for achieving integrated, smart, sustainable, and inclusive cities (Akande et al., 2019). Following a multi-method approach, Brenner and Hartl (2021) examined how different actors express the relationship between digitalization and sustainability in media discourses and which dimension of sustainability is predominant. The Authors found that the evaluation of ecological and economic sustainability (but not

social) is influenced by the extent of digitalization. These findings call for a more nuanced view of sustainability that represents better its multifaced dimensionality, with a particular focus on the social dimension, to be promoted by multiple actors, like policy-makers and interested stakeholders.

Starting from the awareness of the scarcity of studies mapping digital transition in the environmental sustainability domain, Feroz et al. (2021) conducted a systematic literature review on the disruptions driven by digital transformations, which were organized in four key areas: pollution control, waste management, sustainable production, and urban sustainability. This mapping allowed to propose an agenda for future research in terms of digital transformation strategies, organizational capabilities, and performance in the field of environmental sustainability (Feroz et al., 2021). Examples of these two areas, digitalization, and sustainability, applied in the field of organizations, proliferate, starting from green technologies and production operations to transforming a classic company into a sustainable one. While a considerable amount of attention has been put on these shifts individually, less attention has been devoted to understanding how these trends can be combined. In fact, the possible exchange between these scientific research areas has been recently addressed, as witnessed by a growing number of studies based on the use of digital interventions to change people's behavior in a more sustainable way (Hedin et al., 2019). These behavior change interventions used various techniques, such as gamification, nudging, and persuasive apps, just to mention a few of them (e.g., Comber et al., 2013; Hedin et al., 2019). However, despite the growing number of research studies in this intersection area, there is a clear lack of synthesized knowledge on the types of successful interventions behavior toward sustainable behaviors (SBs).

To fill such a gap, we present a systematic mapping review of the digital technologies used to promote sustainable behaviors, in order to trace trajectories of research in this area and to orientate both future research agenda and policy decision-making. To this end, the review includes an in-depth analysis of 37 selected articles, with a classification scheme (see Supplementary Table 1) showing multiple aspects covered in existing research. From our literature search, it emerged that systematic reviews on the relationship between digitalization and sustainability science have been conducted only for narrowed topics. For example, Hedin et al. (2019) published a systematic review on digital behavior change interventions in the field of sustainable food consumption. Another example of focused topics is the one by Castro et al. (2021), who recently published a holistic review about the confluence of digitalization and sustainability in promoting the Sustainable Development Goals. Specific contexts were considered, like the recent systematic review on the influence of environmental sustainability and digitalization processes on the business development of Small and Medium-sized Enterprises, SMEs (Isensee et al., 2020). It is worth noting that a recent mapping study has been published on the general and active use of only one category of digital technologies, i.e., serious games and gamification, to promote sustainable behaviors (De Salas et al., 2022). To create successful techniques to encourage environmentally friendly behavior, it is crucial to comprehend the psychological elements that underlie sustainable behavior. Indeed, intention to act is a strong indicator of action, according to psychological theories like Ajzen (1991), and knowing the variables that affect intention can help in designing interventions that will effectively encourage

sustainable habits. Additionally, habits and social norms have a big impact on behavior, thus it's necessary to comprehend these psychological aspects before designing interventions (Piras et al., 2021; Dessi et al., 2022; Bonaiuto et al., 2023). Different key theories informing sustainable technology adoption in a pro-environmental direction are available as potential frameworks to understand the attitude-behavior gap. These include the Diffusion of Innovations Theory (Rogers, 2010), the Technology Acceptance Model (Davis, 1989), and the Value-Belief-Norm Theory (Stern, 2000). Some typologies of digital technologies, like smart grids or virtual reality apps and games, can be considered as early-stage innovations. According to the Diffusion of Innovations Theory (Rogers, 2010), innovations are adopted through different stages, defining so five categories of adopters (i.e., innovators, early adopters, early-users, early majority, laggards) influenced by the characteristics of the innovation itself, communication channels, time, and the existing social context in which the innovation is developed. Another model that can be used as a useful framework connecting the psychology of sustainable behaviors and the use of digital technologies is the Technology Acceptance Model (Davis, 1989), which describes perceived usefulness and perceived ease of use as two key determinants of the adoption of various technologies. Different theories and models have been developed to explain several types of SBs. A review of these theories is outside the aim of this paper, however, one of the most used theories is the Value-Belief-Norm Theory (Stern, 2000). According to this theory, behavior is explained by a chain of sequential variables: biospheric and altruistic personal values predict ecological worldview, which gives rise to the awareness of consequences for the environment, that in turn increases the ascription of responsibility to the self for such consequences. Finally, this sequence triggers the sense of obligation to take action (i.e., the moral norm) which predicts the congruent pro-environmental behavior (Stern, 2000). Thus, personal values are foundational factors that influence SBs.

These theories and constructs could be helpful in shedding light on how to encourage environmentally responsible behavior and, eventually, contribute to a healthy world by approaching the issues of digital technology and sustainability from a psychological viewpoint. Indeed, digitalization could be viewed as a resource to close the gap between intention and action for sustainable lifestyles. Digital tools, like serious games, mobile apps, and smart meters, can have the potential to inspire sustainable behaviors and maintain them over time, stimulating personal engagement through the use of social norms and profiting, for example, from gamification approaches to support behavior change.

1.1 Objective and research questions

This contribution aims to systematically map the literature about digital behavior change interventions for actively promoting SBs, with the scope of improving the knowledge on the role that digital technologies can have in triggering individuals' and groups' sustainable actions. Specifically, this systematic mapping review is built to answer these research questions:

RQ 1 What are the main bibliometric characteristics of the selected articles?

This research question intends to find out the number of published articles in the selected period, the year of publication, and the places where the studies have been published.

RQ 1.1 What is the distribution of selected articles for years of publication?

RQ 1.2 What geographical distributions are being covered?

RQ 2 Which method features are represented in the selected articles?

This research question aims to analyze a set of method characteristics, including research types and approaches used, and areas targeted for data extraction.

RQ 2.1 Which research design was used to conduct the studies?

RQ 2.2 Which sampling technique was adopted?

RQ 2.3 What are the types of digital technologies and SBs in the selected studies? And what is the impact of the first ones on the second ones?

The main aim here is to detect the key facets of digital technologies (and their impact) involved in the promotion of sustainable behaviors.

RQ 3.1 What are the main digital technologies used to promote environmental sustainability?

RQ 3.2 What are the main SBs investigated?

RQ 3.3 How much evidence is available for long-term impacts - what is the actual length of studies?

RQ 3.4 For whom digital interventions are programmed?

RQ 3.5 What evidence is there concerning the efficacy of digital technologies interventions in promoting SBs?

2 Method

To provide an answer to the research questions, we carried out a systematic map (SM), a synthesis method whose aim is to collect, catalog, and describe the available evidence related to a broad topic (James et al., 2016), firstly conducted in the social sciences (Bates et al., 2007; Clapton et al., 2009) and then adapted for its use in environmental management and conservation science (Randall and James, 2012). SMs can be useful in providing reliable knowledge for researchers, decision-makers, and practitioners, for instance by helping to identify domains of knowledge requiring further research and/or reliable data suggesting best practices in a given domain (Haddaway et al., 2016). The ROSES (RepOrting standards for Systematic Evidence Syntheses; Haddaway et al., 2018) protocol, which is tailored to environmental systematic reviews and maps, consistently with Collaboration for Environmental Evidence (CEE)

guidelines (Collaboration for Environmental Evidence, 2018; Haddaway et al., 2018), has been adopted to carry out the SM.

2.1 Search strategy

To retrieve primary studies focused on digital technologies' use for promoting SBs, the following search strategy was adopted. Starting in June and ending in November 2020, we performed a comprehensive literature search in different databases (Web of Science, Scopus, PsycArticles, and ERIC). To this aim, the following combination of keywords related both to the intervention (use of different types of digital technologies) and the outcomes (SBs), was adopted and combined through Boolean operators: ("sustainable behavior" OR "pro-environmental behavior" OR "environmental behavior" OR "environmental psychology" OR "conservation behavior" OR "environmentally significant behavior" OR "environmentally supportive behavior" OR "ecological behavior") AND ("technology" OR "simulation" OR "virtual reality" OR "digital games" OR "serious games" OR "artificial intelligence" OR "multimedia" OR "video" OR "software" OR "mobile" OR "information systems" OR "e-learning" OR "internet of things" OR "learning systems" OR "robot" OR "computer" OR "audio-visual" OR "virtual learning environment").

2.2 Eligibility criteria

We adopted the following inclusion criteria for our SM review: (a) studies had to investigate the implementation of digital technologies interventions (Independent Variable) to promote SBs (Dependent Variable); (b) studies using different methods (i.e., qualitative, quantitative, or mixed methods) measuring the effect (experimental, lab-based, quasi-experimental, mixed methods, or field experiment) of digital technologies interventions through comparator (temporal - within-subjects - or experimental - between subjects - manipulation, mixed methods); (c) studies had to be published in the last 10 years (from January 2010 till November 2020) and had to be available in one of the following languages: English, Italian, Spanish, or French; (d) studies had to be published in academic and scholarly peer-reviewed journals. No constraints were planned for the reference populations. We also chose to exclude the following contributions: (a) work-in-progress studies, short papers, Ph.D. dissertations, and congress proceedings; (b) theoretical papers or cross-sectional and correlational studies; (c) digital interventions that have not been implemented (e.g., papers describing only the programming of a web app); (d) digital technologies only described but non used for an active intervention; (e) digital technologies not used as an antecedent of SBs; (f) interventions not been evaluated from a behavior change perspective; (g) interventions covering aspects other than the ones directly linked to SBs; (h) case studies without any inference; (i) model simulation studies; (j) studies with referenced links to other complementary evidence; (k) studies lacking fundamental information. Using the predefined eligibility criteria detailed above, papers were selected according to a three-stage hierarchical screening processing order to establish their eligibility: first, papers were evaluated considering language and documents' type, subsequently by title, abstract, and

keywords, and finally considering the full-text. Those papers for which there were doubts or insufficient information for the decision were retained for assessment at a later stage.

2.3 Categorization criteria

A concept-centric review was performed, on the basis of categories related to the type of digital technology employed for the promotion of different kinds of SBs. Research in the field was classified by using a coding scheme (Supplementary Table S1) in which the investigated dimensions (i.e., study characteristics like sampling strategies and research design; intervention characteristics like the employed digital technology and the promoted SBs; investigated outcome and population characteristics) are presented according to the ROSES framework.

3 Results and discussion

In total, 1,269 articles were retrieved (Figure 1). Duplicates ($n = 325$) were removed, and the articles screened for title, abstract, and keywords were 944. Consistently with the eligibility criteria, we excluded 890 of them, reaching a number of 53¹ articles for the full-text screening. Subsequent analysis led to the exclusion of 4 studies for intervention-related reasons (i.e., technology not used as dependent variable), 7 studies for design-related reasons (i.e., a technology used as a mere instrument, with no empirical study), and 2 studies because they were duplicates but published with different versions. In sum, 40 articles were included after the full-text screening. Finally, 3 articles were removed because they belonged to gray literature (2 conference proceedings and 1 Ph.D. dissertation), and thus a definitive total of 37 studies were included in the review.

3.1 RQ 1: bibliometric characteristics of the selected articles

The recency and the increase of scientific interest in this topic are demonstrated by the distribution of the selected papers by year of publication, presented in Figure 2.

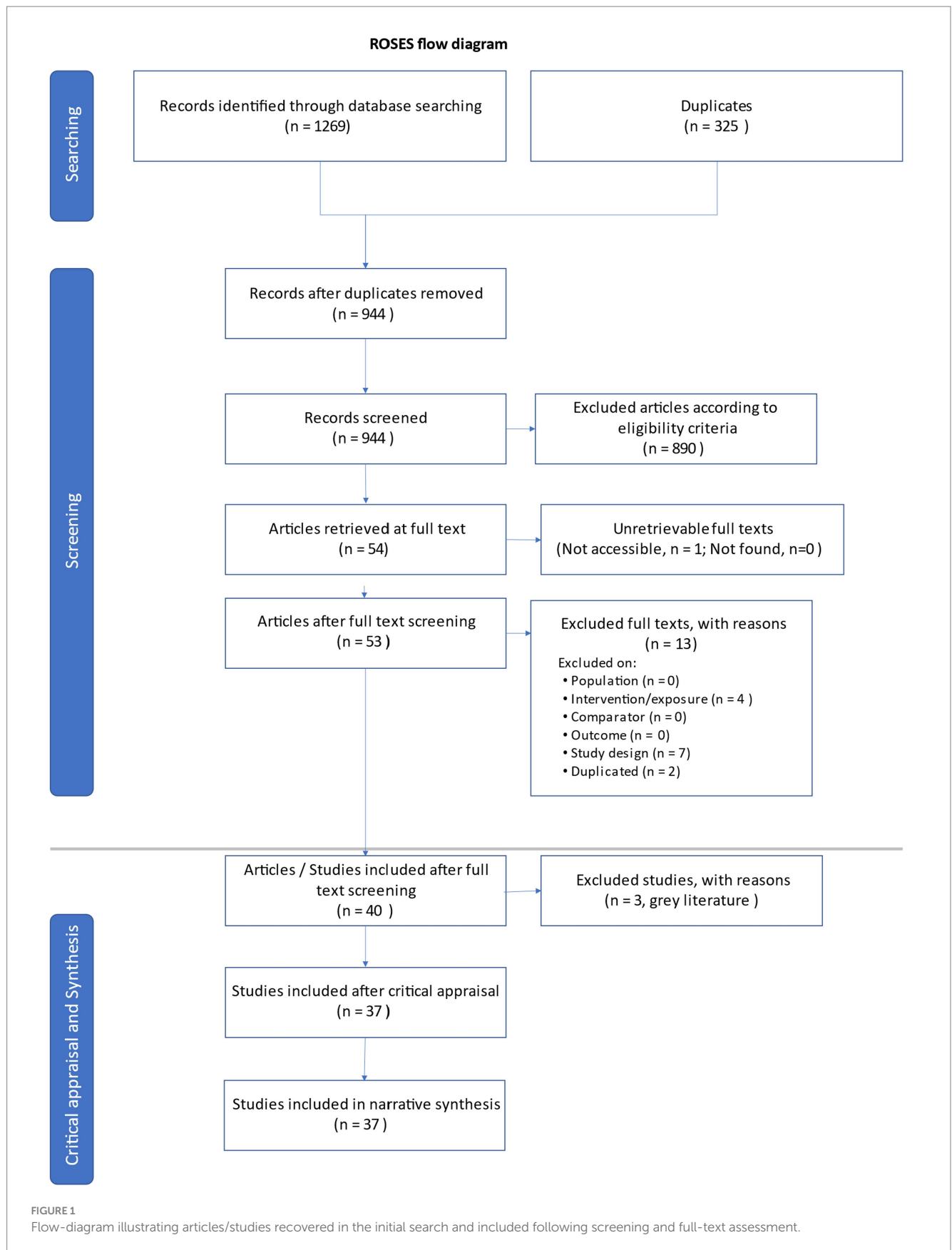
In the considered publication time (2011–2020) there is a year-after-year increase in the number of published studies, with one occasional slowdown occurring in 2017.

Regarding geographical distribution, the following picture emerged (see Figure 3).

Studies from a total of 43² countries were found with most studies originating in North America (e.g., United States of America (USA) – 25.58%, Canada 2.32%), United Kingdom (UK): 18.60%, and Europe

1 The number was initially 54, but one article was excluded because not accessible.

2 The final number of countries does not correspond to the number of selected studies because in some cases the same study was conducted simultaneously in multiple countries (e.g., Casado-Mansilla et al., 2020).



(e.g., Germany: 11.63%, Spain: 4.65%, Italy: 4.65%, Switzerland 4.65%, Greece 4.65%, Netherlands 2.32%, Sweden 2.32%), few from Asia (e.g., Malaysia: 2.32%, Taiwan: 2.32%, Korea: 2.32%, Indonesia: 2.32%,

Japan: 2.32%), and few from Oceania (Australia: 2.32%, New Zealand: 2.32%), in some respects, reflecting the geographic spread of OECD countries around the globe, except for the Asian countries.

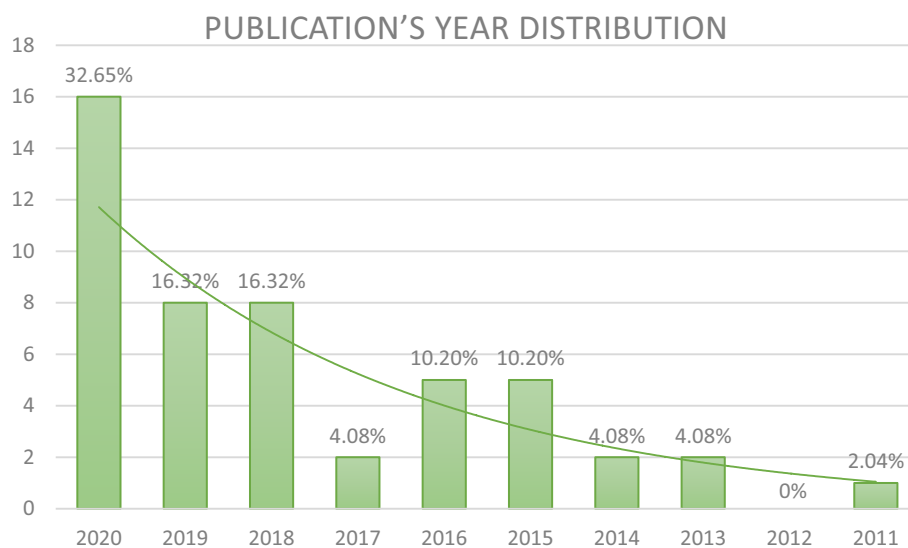


FIGURE 2
Publication's year distribution of the screened articles.

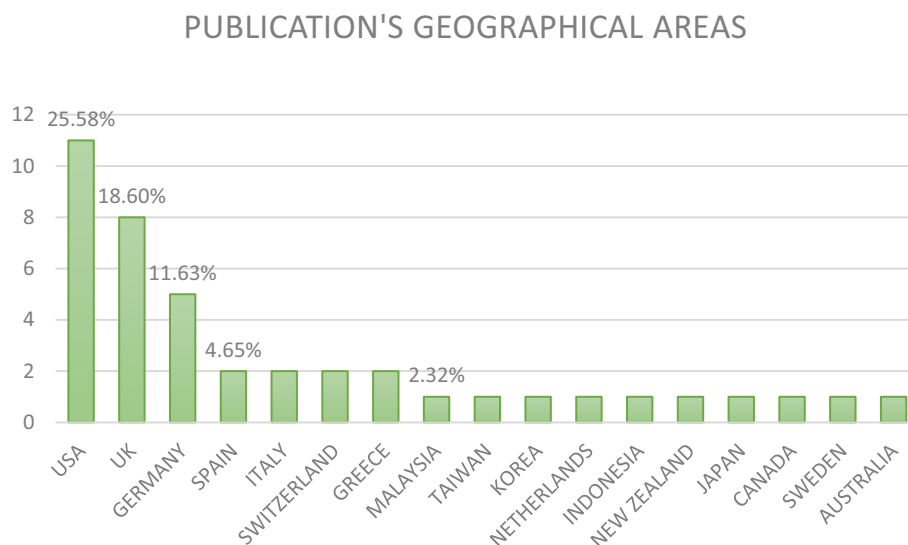


FIGURE 3
Geographical distribution of the screened articles.

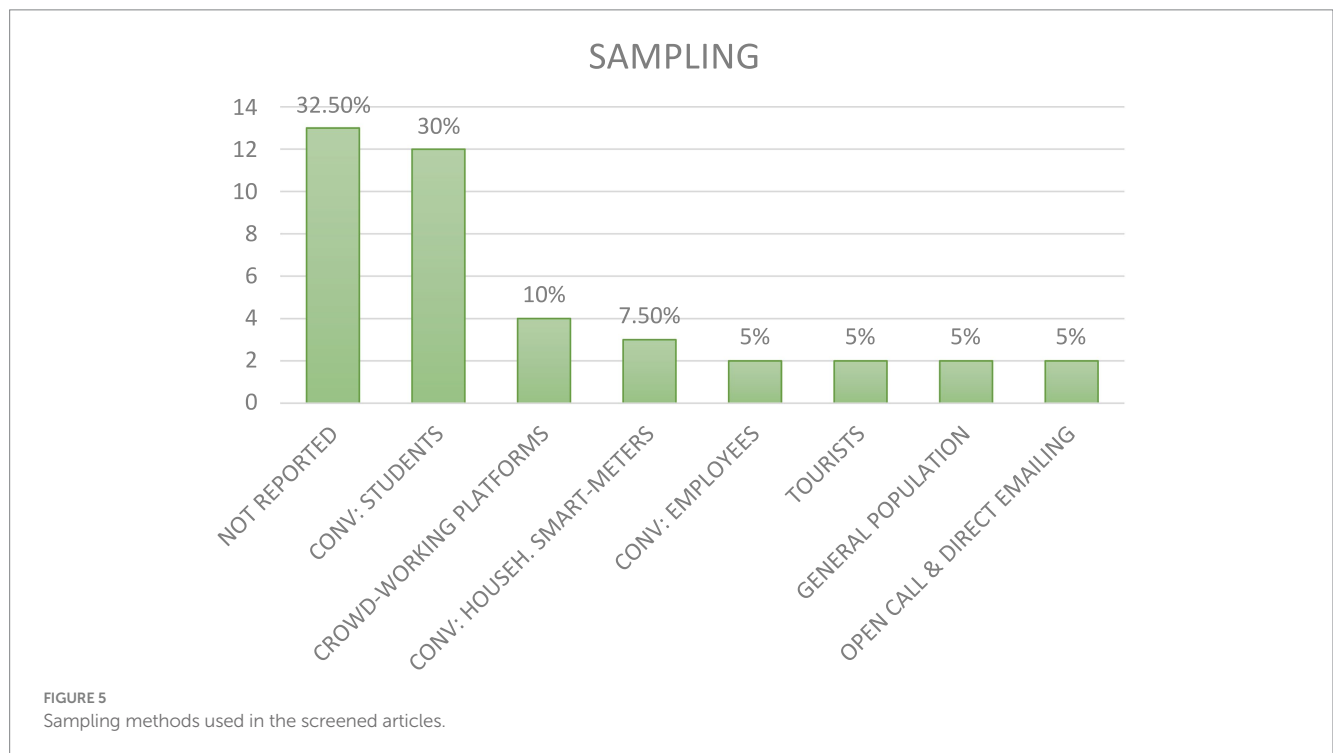
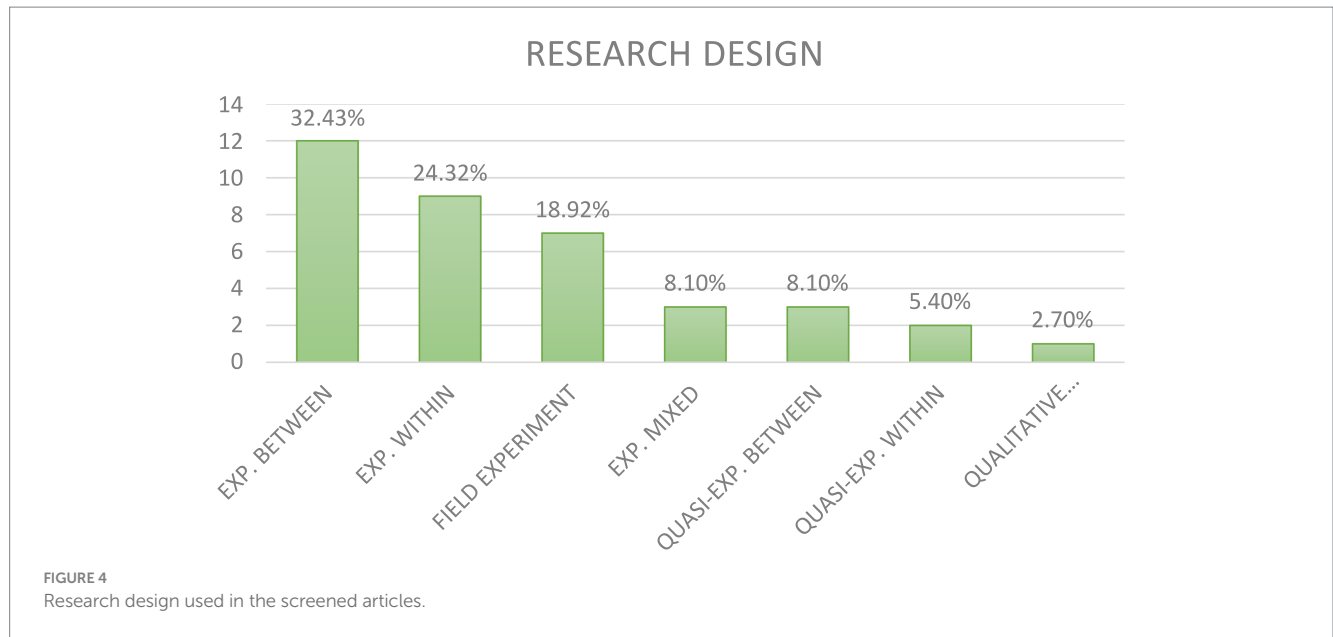
3.2 RQ 2 research type facets

Regarding the kind of research design, the following picture emerged (Figure 4).

The majority of published articles (64.86%) used an experimental research design (between-subject design: 32.43%, within-subject design: 24.32%, mixed design: 8.10%); a total of 13.51% of studies used a quasi-experimental design (between-subject design: 8.10%, within-subject design: 5.40%); and another cluster emerging from our analysis is one related to field experiments (18.92%). About the sampling method, the following picture emerged (Figure 5).

Most studies³ employed convenience sampling techniques used with the following targets: students (30%, voluntarily participation or participation in the exchange of course credits); employees (5%), or clients from households with installed smart-meters (7.50%); crowd-working platforms (e.g., M-Turk) (10%) volunteers from the general

³ The total number of sampling techniques used does not correspond to the number of selected studies because in some cases the same study was conducted simultaneously in multiple countries (e.g., Moore and Yang, 2020) or the sample was mixed (e.g., students and the general population; Nelson et al., 2020).



population (5%), open call and direct emailing (5%), tourists (5%). Moreover, 32.50% of studies did not report information about the sampling procedure.

3.3 RQ 3: technology type

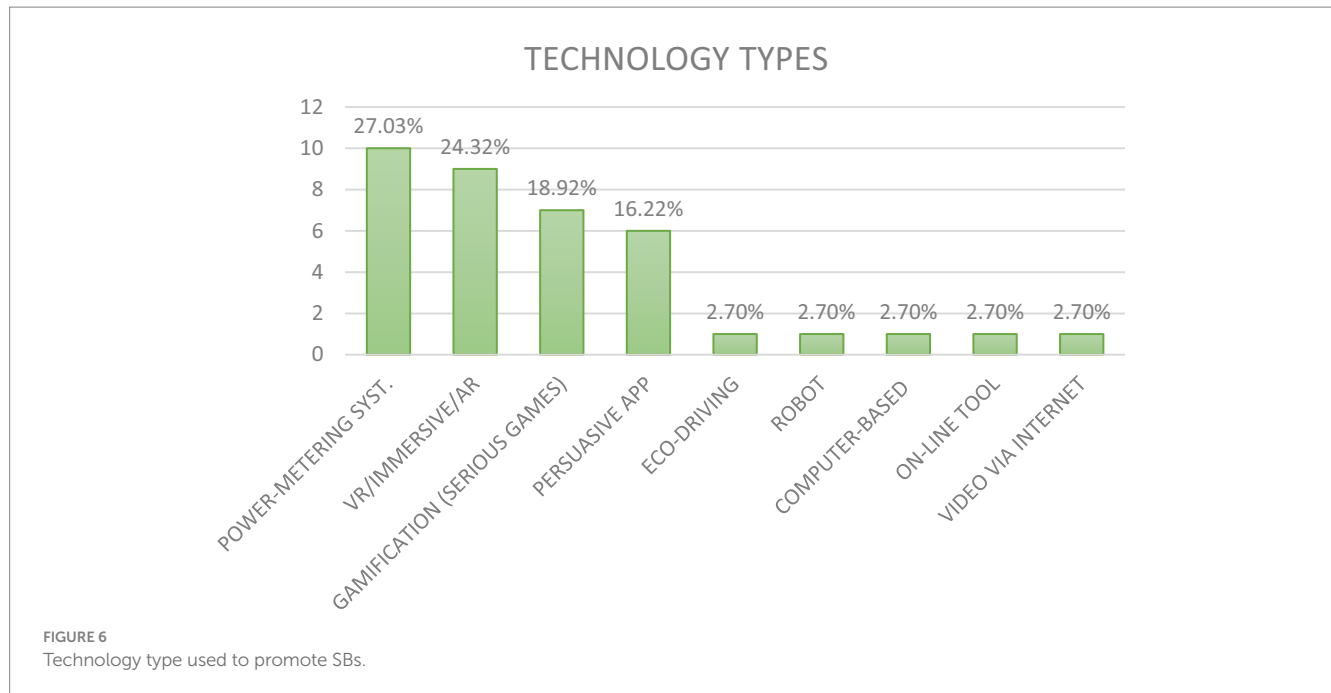
About the digital technologies used to promote environmental sustainability, the following picture emerged (see [Figure 6](#)).

The digital technologies used to promote the SBs investigated were the following: Power-metering system (27.03%); Virtual Reality/Immersive Reality/Augmented Reality (24.32%); Gamification

(18.92%) and Persuasive mobile app (16.22%); Eco-driving (2.70%); Video administered via the internet (2.70%); Computer-based learning environments (2.70%); On-line tools (2.70%); and Persuasive robots (2.70%). In the following paragraphs, evidence that emerged for each digital technology is described.

3.3.1 Power metering systems

Power metering systems include IT systems used to measure resource consumption (e.g., electricity, gas, water) and make this information accessible to the user, such as (a) *smart meters* (IT systems collecting the electricity consumption at a high frequency and transmitting it to a data hub); (b) *smart shower-meters* (IT systems



providing feedback on energy and water consumption in real-time); and (c) *eco-feedback technologies* (technology that provides feedback on individual or group pro-environmental behaviors to manage environmental impact). Empirical evidence about these three kinds of systems is addressed in the following paragraphs (see Table 1).

3.3.1.1 Smart-meters

Chiu et al. (2020) conducted a between-subject experiment with smart electronic sockets to collect the electricity use information on a personal computer, and a mobile app to register the measured data instantly. This intervention obtained the following results: (a) a reduction of personal use of electricity by more than half of the participants; (b) greater efficacy for the “Providing comparative personal power usage information” experimental condition: 67% of participants reduced their electricity use (Chiu et al., 2020).

The role of smart-meter-based feedback interventions was investigated also by Henn et al. (2019) in a quasi-experiment conducted in Germany, where a local energy supplier provided smart-meters to all its customers’ households. Participants could access a web-based feedback portal with individual information about their household’s electricity use. This latter was provided in different formats: per day, per quarter year, or as a trend (whether electricity use was higher or lesser compared with previous levels of consumption: 2008–2012). It was found that only people who held a certain level of environmental attitude, like having rigor in using the provided information, saved more energy in the feedback portal compared to the control group (Henn et al., 2019). In other words, a passive attitude- i.e., registering for a web portal - not sufficient but active involvement is needed.

A living lab setting of seven households lasting 18 months was instead developed by Schwartz et al. (2015) for implementing a Home Energy Management System (HEMS) that provided feedback through TV, PC, smartphones, and tablet-based interfaces. The Authors found a 7.8% drop in electricity consumption compared to the year preceding the 18 months of HEMS. Another study on the role of

normative feedback (financial vs. environmental) in promoting pro-environmental decision-making behavior, i.e., home heating (heat pump), was conducted in a 2 × 2 (plus control) choice experiment with a sample of the United Kingdom general public. Participants could choose between a typical heating system (a gas boiler) and a relatively more energy-efficient alternative (heat pump). In the normative information condition, respondents chose the more energy-efficient alternative in both financial and environmental feedback; however, when no normative information was provided, only financial but not environmental input worked in the direction of more energy sustainable choices. The main effect of normative information on behavioral intentions was replicated (albeit only for homeowners), but there was no significant interaction between normative condition (present vs. absent) and feedback type, controlling for home ownership status (Hafner et al., 2019).

A final example, regarding smart-meters, is the GreenSoul (GS) project, conducted in tertiary buildings (Casado-Mansilla et al., 2020). GS is based on monitoring devices of shared and personal equipment, such as Lighting, Heating Ventilator, Air Conditioning, and appliances with different feedback, e.g., creating, enhancing, or confirming an energy-saving behavior. The Authors implemented a recommendation-based intervention through ICT with a pre-post experimental design showing that the three most effective Persuasive Principles (PPs) in a working environment were “Cause and Effect,” “Conditioning,” and “Self-monitoring” (Casado-Mansilla et al., 2020).

3.3.1.2 Smart shower meters

In a large-scale field experiment, Tiefenbeck et al. (2019) provided real-time feedback to participants on their showering habits. The intervention lowered water use for the target behavior by 22%, resulting in substantially greater absolute conservation gains compared to traditional policy interventions, based on aggregated feedback. The method is inexpensive, technically suited to the great majority of families, and yielded daily savings of 1.2 kWh for each household, which is greater than the average energy use for lighting.

TABLE 1 Studies employing smart-meters technologies.

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome measures	Moderators	Results	Intention/ Behavior
1	Chiu et al. (2020)	N Students = 30 (N females = 10, N males = 20, aged 21–24)	Journal of Cleaner Production	Within subject (1 condition per week): “No information provided” (no feed-back) vs. “Personal information on electricity compared with peers” (actual individual eco-feedback); “Providing information on sustainable use of electricity” (persuasive eco-feedback); “Providing information on electricity compared to peers and giving awards for sustainable use” quarter (group eco-feedback and reward).	Smart/intelligent devices, eco-feedback and persuasive strategies	1. Behavioral intentions for sustainability 2. Energy consumption	/	+ Successful reduction of personal use of electricity by more than 50% of the participants. + “Providing comparative personal power usage information” had the greatest effect: 67% reduced their usage. = No significant difference between “Providing personal power usage information” and “No information provided.”	Behavior
2	Henn et al. (2019)	N Participants = 186 (23.7% females; 5.4% did not indicate their gender; M age = 56.5, sd = 11.0)	Journal of Environmental Psychology	Quasi-experimental between subject design: voluntarily registered to smart-meter feed-back program (N = 127) vs. not registered (N = 59)	Smart-meter based feed-back interventions	1. Amount of energy saved in kWh (observed period 2008–2012)	(a) Environmental attitude	+ Increased energy savings for the ones registered in the smartemeter program, especially for the ones with higher environmental attitude levels (moderation effect).	Behavior
3	Schwartz et al. (2015)	N Households = 7 (2 Couples, 2 Single, 3 Families), N Participants = 16 (N females = 9, N males = 7; aged 5–66, M age = 33.06)	Interacting with Computers	Longitudinal qualitative study (18 months)	Feedback systems in Sustainable Interaction Design	1. Reduction in electricity consumption	/	+ 7.8% average reduction in electricity during a period of 18 months when compared with the consumption in the year before the HEMS deployment.	Behavior

(Continued)

TABLE 1 (Continued)

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome measures	Moderators	Results	Intention/ Behavior
4	Hafner et al. (2019)	N Participants = 599 (N females = 390, N males = 202, N undisclosed = 2, Missing = 5, aged 18–72, age median = 34)	Environmental Education Research	2 (normative information: yes vs. no) x 2 (feedback type: financial vs. environmental) and a control condition (random assignment) who received no normative information and no feedback information	Feedback via internet	1. Pro-environmental decision-making behavior 2. Pro-environmental purchasing	/	+ There was low uptake of the heat pump in the control condition where no frame information was provided. Yet, in both conditions where normative information was provided, respondents were significantly more likely (vs. control) to choose the heat pump, advancing understanding of normative social influence in the context of pro-environmental purchase behavior. When normative information was not provided, only financial but not environmental, feedback was associated with a significantly greater likelihood of heat pump choice. = The main effect of normative information was replicated for behavioral intentions (though only for homeowners), but there was no norm-feedback interaction (regardless of homeownership).	Behavioral intention
5	Casado-Mansilla et al. (2020)	N Participants Pre = 303; N Participants Post = 105	Energies	Experimental within subject design (pre-post)	GreenSoul (GS): smart-meter with personalized feedback	1. Promotion of pro-environmental behavior 2. Promotion of energy conservation	/	+ The three most effective Persuasive Principles (PPs) for changing energy-related behavior in a working environment are “Cause and Effect,” “Conditioning,” and “Self-monitoring.”	Behavior
6	Tiefenbeck et al. (2018)	N Households = 620	Management Science	Framed field experiment	Smart shower meter	1. Promotion of pro-environmental behavior 2. Promotion of energy conservation	/	+ Real-time feedback reduced resource consumption for the target behavior by 22%. High baseline users displayed a larger conservation effect, in line with the notion that realtime feedback helps eliminate “slack” in resource use.	Behavior
7	Tiefenbeck et al. (2019)	N Hotels = 6, N rooms = 256, N observations = 19,596	Nature Energy	Field Experiment in collaboration with 6 hotels (randomized control trial)	Real-time feedback	1. Promoting energy conservation behavior	/	+ The treatment group used 0.215 kWh less energy each shower than the control group, which used 1.883 kWh. This indicates a 11.4% decrease. When flow rate is controlled, the effect is still quite significant, with a decrease of 0.188 kWh, or 10.0%.	Behavior

(Continued)

TABLE 1 (Continued)

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome measures	Moderators	Results	Intention/Behavior
8	Pereira-Doel et al. (2019)	N showers = 1.962 (N treatment group = 1.048, N control group = 914)	e-Review of Tourism Research	Covered Field Experiment between subject design; treatment (guests could see the timing for their ongoing showers in the Display) vs. control (the Display was not installed and hence the timing could not be seen, so guests were not nudged)	Real-time feedback provided by smart water-saving technology (trough Aguardio)	1. Pro-environmental behaviors	/	+ The Aguardio effect of this intervention is large and highly significant: guests who received real-time feedback used on average 40.91 less seconds (mean = 4 min 58 s) than guests in the control group (mean = 5 min 39 s). This represents an average reduction of 12.06%. The independent t-test showed that the difference between groups was statistically significant.	Behavior
9	Chen and Sintov (2016)	N Participants = 856 (54.9% females; M age = 47.1, sd = 17.8)	Energy Research and Social Science	Survey	Website, mobile phone application, in-home display	1. Encouraging connection with nature 2. Promotion of pro-environmental behaviors 3. Promotion of energy conservation 4. Adoption of sustainable innovations	/	+ According to the regression results, nature connectedness was the best predictor of all outcomes, with higher nature connectedness predicting a higher chance of technology and program uptake. The connection with nature can aid in “bridging the logic gap” between the adoption of sustainable innovations and environmental conservation.	Behavioral Intention
10	Mozo-Reyes et al. (2016)	/	Resources, Conservation and Recycling	Experimental design - Mixed methods (three experiments divided by length: 2 days, 1 week, 1 month)	Eco-feedback technology	1. Pro-environmental behaviors 2. Promote recycling activities	/	+ Two day experiment: 95% probability that the number of visits (persons who used the bin to recycle) and recycled items were significantly higher at the WeRe-cycle Bin than the baseline bin. One week experiment: the highest recycling rate in one bin during the baseline week was significantly lower than the recycling on the WeRecycle bin. One month experiment: 99% probability of increased recycled items during the WeRecycle intervention.	Behavior

(Continued)

This intervention showed how digitization could make information available to energy users, allowing them to overcome salience bias and behave according to their preferences (Tiefenbeck et al., 2019). In another large-scale field experiment conducted by Tiefenbeck et al. (2019), participants received real-time feedback on their showering activity to encourage water consumption reduction. Results showed that treatment effects were large (11.4% reduction in water use), indicating substantial water conservation among participants who did not opt-in and in a context where participants were not financially responsible for energy costs.

Another study demonstrating the effectiveness of real-time feedback provided by smart water-saving technology for shortening shower time was the field experiment run by Pereira-Doel et al. (2019) who showed a 12.06% reduction in showering time ($N=1,962$) confirming that real-time feedback is efficient in stimulating sustainable behavior choices. Chen and Sintov (2016) analyzed the intentions to adopt energy management technologies and programs (e.g., a free website, smartphone app, and in-home display monitor) to handle home electricity consumption. Findings revealed that nature connectedness, alongside digital technology use, was associated strongly with all measured outcomes, suggesting that a positive relationship with nature might help bridging the logical gap between the adoption of sustainable innovations and environmental protection.

3.3.1.3 Eco-feedback technologies

Mozo-Reyes et al. (2016) used a low-cost, low-energy electronic recycling bin design named “WeRecycle bin”, that is programmed on human-computer interaction and social fundamentals to provide persuasive eco-feedbacks. Using mixed-methods research, the WeRecycle bin obtained positive responses in three different experiments, with different social settings and exposure time, demonstrating impacts for public recycling. The investigated studies about power-metering systems showed the great potential of these technologies in promoting SBs in the building residential sector, which is by far the world’s largest energy consumer and emitter. Indeed, residential buildings offer great potential and cost-effectiveness in improving energy efficiency and carbon mitigation, consistently with the Paris UN Conference climate goals (Bastida et al., 2019; Chen et al., 2023; Xiang et al., 2023; Zou et al., 2023).

Power-metering could also potentially provide solutions to some of the challenges faced by the energy industry: decarbonization, decentralization, and digitalization, in order to empower European Union consumers (Andoni et al., 2019). Moreover, such technologies can be easily adapted to multiple contexts, both public and private, like schools, hospitals, offices, and universities.

3.3.2 Virtual reality

The term *virtual reality* (VR) refers to “a wide variety of computer-based applications commonly associated with immersive, highly visual, 3D characteristics that allow the participant to look about and navigate within a seemingly real or physical world” (Lopreato, 2016, p. 40). It has received great attention for its ability to increase the individual’s sense of presence, which is commonly described as the feeling of “being there” (Grassini et al., 2020) which is supposed to influence emotions and, in turn, allow a better connection to the target situation (see Table 2).

In VR research related to SBs, we can distinguish studies using different tools, such as 360-degree videos, immersive virtual environments (IVEs), video games with vividly rendered settings, and

augmented reality (AR). Each tool is addressed in the following paragraphs.

As regards the 360-degree video feature, it offers a full panoramic view of the scenery, as the user manages the video’s perspective (Feng, 2018). 360° videos became one of the most promising tools to communicate news and scientific information due to their capability to offer a highly realistic media experience and accessibility (Schild, 2020). This technology was used in video presentations in a controlled laboratory setting to stimulate the participants’ environment protection and content perception (Oh et al., 2020). Results showed an enhancement of the perception of modality interactivity and, in turn, greater perceived fun (but not credibility), as well as intention to protect the environment in terms of promotion (but not prevention) in the 360° video compared to unidirectional videos (Oh et al., 2020). A similar experiment was realized in a laboratory setting where the exposure to a video on natural vs. built environments was offered with a head-mounted display compared with a traditional computer monitor (Soliman et al., 2017). Results showed that the content of the video mattered and influenced attitude toward nature (built vs. natural environment), while the type of technology (computer monitor vs. head-mounted display) had no impact. Moreover, experimental manipulation increased the perception of nature connectedness but it did not meaningfully impact different pro-environmental behaviors. Lastly, technology type (desktop or less immersive or head-mounted display or more immersive) did not influence the dependent variables. VR was also used in a 2 (positive vs. negative framing) $\times$ 2 (unidirectional video vs. 360° video) field experiment about the coral reef crisis showing that visual communication increases the amount of donation to a charity organization (Nelson et al., 2020). The Authors suggest that risk communication can be tailored according to different targets. In their studies, they recruited different samples (students, the general population, and tourists): in particular, among the tourist sample the 360° film with a negative message evoked a larger amount of donations. In conclusion, all treatments significantly influenced emotions and the sense of presence in comparison to no media communication (with the highest levels in the 360° VR condition).

Regarding Immersive Virtual Environments, these are digital devices based on vivid layers of sensory information in a simulated environment (Blascovich and Bailenson, 2011). Ahn et al. (2014) conducted two different studies to analyze the power of embodied experiences within IVEs by comparing the effects of cutting a virtual tree vs. reading a print description of the same operation (Study 1) or watching a video about tree-cutting to promote paper conservation (Study 2). In IVEs users may feel negative future consequences of actions, like the personal contribution to deforestation, as if they were occurring in the moment of simulated experience. The simulated experience was very vivid: spatialized audio information was conveyed through earphones to mimic realistic sounds of the forest; moreover, the computer was also equipped with a force-feedback haptic joystick (Sensible Phantom Omni) to allow real-time interaction with objects in the IVE. In Study 1, there was a significant increase in the internal environmental locus of control in both experimental conditions. The observed behavioral measure chosen was napkins usage: participants in the IVE condition used 20% fewer napkins immediately after the treatment in comparison to the ones in the print condition. In Study 2, interesting effects were observed after 1 week (at T2): the effect of IVEs on environmental locus of control and behavior was consistently stronger compared to the other conditions. In another study

TABLE 2 Studies based on virtual reality.

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome Measures	Moderators	Results	Intention/ Behavior
11	Oh et al. (2020)	N Students = 76 (N females = 53, N males = 23, aged 18–28, M Age = 19.57)	Science Communication	Lab Experiment (between-subjects design): 360-degree condition vs. unidirectional condition	Virtual environment: 360 degree video	1. Perceived Interactivity 2. Self-efficacy to protect the environment 3. Behavioral intention to protect the environment (promotion, prevention) 4. Message Perception (fun, credibility) 5. Issue Involvement	(a) Environmental Self-efficacy	+ Enhancement of perception of modality interactivity and in turn greater perceived fun, (but not credibility) and intention to protect the environment in terms of promotion (but not prevention). + Increased perceived fun and credibility of the video content and greater reduction intention to protect the environment only for high environmental self-efficacy participants (moderation effect).	Behavioral intention
12	Soliman et al. (2017)	N Participants = 227 (N females = 158, N males = 67, N other = 1, N undisclosed = 1, M age = 21.20, sd = 6.42)	Journal of Media Psychology	Experimental design: 2 (video: natural vs. built environment) x 2 (display device: desktop screen vs. headmounted display)	Immersive technology	1. Nature Connectedness (Inclusion of nature in the self, Connectedness to Nature Scale) 2. Pro-environmental behaviors	/	+ Influence of type of video but not of technology on Nature Connectedness; = no influence on three different observed pro-environmental behaviors.	Behavior
13	Nelson et al., 2020	N Participants = 1,006 divided in: N students = 487 (55% females, M age = 20.4, sd = 3.55); N general public = 248 (47% females, M age 23.2, sd = 9.22); N tourists = 271 (55% females; M age 29.3, sd = 10.25)	Plos One	2 (framing: positive vs. negative) x 2 (experimental design: 360-degree condition vs. unidirectional condition) and control condition	Virtual Reality	1. Donations to a conservation charity organization, Emotions, Sense of presence	/	+ Both positive and negative framing, and low and high visual immersion significantly affect donations to a charity in comparison to no media communication. = No significant differences between experimental condition in the intention to donate to a charity organization; + Both positive and negative framing, and low and high visual immersion significantly affect emotional responses and sense of presence in comparison to no media communication (with the highest scores in the 360° VR treatment). + Among the tourist sample the 360° film with a negative message evoked the larger amount of donations.	Behavioral intention

(Continued)

TABLE 2 (Continued)

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome Measures	Moderators	Results	Intention/ Behavior
14	Ahn et al. (2014)	1. <i>N</i> Students = 47 (<i>N</i> females = 29, <i>N</i> males = 18, aged 18–46, <i>M</i> age = 21.60, <i>sd</i> = 4.27); 2. <i>N</i> = 60 (<i>N</i> females = 45, <i>N</i> males = 15, aged 18–24, <i>M</i> age = 20.32, <i>sd</i> = 1.16)	Computers in Human Behavior	1. Experimental design (between/within subject): IVE (<i>N</i> = 24) vs. print (<i>N</i> = 23) version; 2. Experimental design (between subject): IVE (<i>N</i> = 21) vs. print (<i>N</i> = 20) vs. video version (<i>N</i> = 19) in two times (T1 and T2 after one week)	Immersive Virtual Environment	1. Environmental locus of control, observed Environmental behavior (i.e., number of napkins used to clean a table) 2. Environmental locus of control, Environmental behavioral Intention, measured Environmental behavior	/	Study 1.+ Participants who embodied the experience of cutting down a virtual tree used 20% less napkins compared to participants in the print condition. + There was a significant increase in internal environmental locus of control immediately following both experimental treatments. Study 2.+ The effect of IVEs on environmental locus of control and behavior was consistently stronger than print and video at T2. = The effects between print and video were not significantly different across all measures at T2. The relationship between experimental conditions and environmental behaviors was mediated by environmental locus of control, but only at T2.	Behavior
15	Chirico et al. (2021)	<i>N</i> Students = 60 (<i>N</i> females = 35, <i>M</i> age = 26.63, <i>sd</i> = 11.56; <i>N</i> males = 25, <i>M</i> age = 31.24, <i>sd</i> = 15.94)	Virtual Reality	Experimental between-subject design: 1. numerical: presenting statistical evidence of plastic consumption in numeric form; 2. concrete: presenting statistical evidence of plastic consumption through heaps of 3D plastic objects; and 3. mixed: numerical and concrete	Virtual reality	1. Emotions, Sense of presence, Attitude toward the environment, Attitude toward plastic (waste and consumption, use and recycle), Environmentally Responsible Behaviors	/	+ Participants in the concrete and in the mixed condition reported higher levels of all the variables investigated compared to the numerical format. - Numerical format was the least effective across all dimensions. = Concrete and mixed formats were similar.	Behavioral Intention
16	Bailey et al., 2015	<i>N</i> Students = 70 (47.1% females, 52.9% males, aged 18–22, <i>M</i> age = 18.4)	Environment and Behavior	Between Subject Experimental Design: 2 (vivid vs. not vivid scenario) x (personal vs. not personal scenario)	Immersive virtual reality	1. Water temperature 2. Water amount	/	+ Cooler water use in the vivid condition; = No significant effect of personal messages on water temperature; = No interaction effect; = No significant effect on water usage.	Behavior

(Continued)

TABLE 2 (Continued)

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome Measures	Moderators	Results	Intention/ Behavior
17	Fox et al. (2020)	N Students = 190 (N females = 112, N males = 78, aged 18 to 34, M age = 20.25, sd = 2.41)	Telematics and Informatics	Experimental (longitudinal between subject design): 2 (psychological distance: near vs. far) x (risk perception: contingent vs. not contingent)	Virtual environments	1. Time 1 Environmental Behavior; 2. Time 2 Policy Support	/	- Experiencing a close (vs distant) environment lead to lower psychological distance and in turn + Higher perceptions of risk, which lead to+ more environmental behavior and + policy support. + Experiencing a contingent (vs non-contingent) environment lead to higher perception of+ interactivity and in turn+ higher self-efficacy, which lead to+ more environmental behavior and + policy support.	Behavior
18	Coghlan (2020)	N = 75	Journal of Sustainable Tourism	Action design research	Virtual reality interpretive game	1. Pro-environmental reward after the game (e.g., \$10 donation to the Cairns Turtle Rehab Centre) vs. two no pro-environmental selection	/	+ More donations (72% for the game and 60% for the control VR video).	Behavior
19	Coen et al., 2019	N students = 8	Human Affairs	Experimental design (within subject)	Augmented reality	1. Pro-environmental; 2. Environmental awareness	/	+ Improvements of SBs in 7 domains (cost of having single/double glazed windows, electricity consumption, washing machine water temperature, CO ₂ emissions, LED/ traditional incandescent light bulbs, shower water conservation, insulation vs. no insulation). + Increase in environmental awareness.	Behavior
20	Ahn et al. (2015)	N = 114 (N females = 80, N males = 34, aged 18–32, M age = 20.80, sd = 2.05)	Communication Research	Mixed factorial design (T1, T2, T3) and between subject design: control (n = 21), loss x high interactivity (n = 26), loss x low interactivity (n = 21), gain x high interactivity (n = 25), or gain x low interactivity (n = 21)	Virtual environments	1. Environmental response efficacy 2. Environmental behavioral intention 3. Environmental behavior (napkins used to clean a table)	/	+ More napkins were used by participants in the control condition compared to those in experimental ones. Thus, framed virtual experiences succeeded in promoting environmental behavior immediately after exposure +.Gain framed experiences elicited greater environmental behavioral intentions than loss framed experiences immediately after the exposure and also after 1 week (Time 2) = No significant difference at time 3 (Time 3)	Behavior

conducted with VR, [Ahn et al. \(2015\)](#) investigating the impact of receiving any kind of environmental message about deforestation via IVEs, showed a reduction of actual paper consumption by approximately 25% of participants. Furthermore, presenting a gain scenario, i.e., a vivid virtual experience of growing a tree vs. a loss scenario, i.e., the experience of cutting a tree, increased environmental response efficacy immediately after the treatment, which in turn led to greater intentions to engage in pro-environmental actions. One week after the experimental exposure (T2), the effect remained stable; however, framing did not affect self-reported pro-environmental behavior in the longer run, so after 2 weeks (T3). In another study, [Chirico et al. \(2021\)](#), conducted a laboratory experiment to understand how different statistical information formats, i.e., numerical, concrete, and mixed, can enhance VR's persuasive potential for plastic consumption, recycling, and waste. In the IVEs statistical evidence was represented using a visual representation of the corresponding amount (i.e., displaying 10 bottles instead of the number 10) to render the information more concrete. Participants in the concrete and mixed conditions reported higher levels of sustainable behavioral intention compared to the numerical format, while concrete and mixed formats were similar. Another experiment was realized to investigate the impact of vivid and/or personal messages on hot water savings behavior ([Bailey et al., 2015](#)). Participants experienced a virtual shower while wearing a fully immersive virtual reality helmet, in which they received feedback on the amount of energy used to heat and transport the virtual water (with various levels of vividness and/or personalization). The feedback was represented as coal to make energy use consumption more concrete and to represent the harmful effects of energy use due to its association with climate change. Results showed that participants exposed to vivid messages (i.e., images of coal) used a cooler water temperature compared to those exposed to the textual ones.

Video games with vividly rendered settings are also considered Virtual Environments (VEs). In this regard, [Fox et al. \(2020\)](#) tested the effects of a serious game that allowed users to engage in a simulated environmental clean-up. The study examined how manipulations of psychological distance (near vs. far) and interactivity (contingent vs. non-contingent) could influence SBs. In the VE participants navigated down with an avatar in a kayak a polluted river that was described as geographically and temporally close or distant. The river was surrounded by a forest-like 3D environment in which sounds of nature such as flowing water and chanting birds were audible. Experimental manipulations of psychological distance and interactivity influenced perceptions of environmental risk, self-efficacy, policy endorsement, and behavioral intention during the serious game. In the near condition participants perceived a higher perception of environmental risk, which led to greater policy endorsement as well as more SBs outside of the lab setting and at a different time point. Regarding interactivity, in the contingent condition, in which the players experienced immediate consequences of their actions, there were higher levels of environmental efficacy compared to the non-contingent version. Effects remained consistent outside of the lab setting and at different time points, like the ones registered for psychological distance. A case study conducted by [Coghlan \(2020\)](#) explored a “build your own reef” game with tourists, using VR to simulate an immersive, 3D underwater seascape. In this simulated

environment, tourists could emulate a reef they had previously seen, building it up while recognizing the marine elements, like corals and fishes that they had already seen, and trying to know them while answering questions about the marine life that they experienced. Results showed that there was a slightly higher pro-environmental choice in the experimental condition: playing the game brought more donations in comparison to watching a video on the same topic (72% for VR based serious the game and 60% for the control VR video). Concerning AR, it is the real-time merging of virtual three-dimensional objects with the actual environment, representing an advancement of (VEs). Unlike traditional VEs, AR allows users to interact with virtual elements in a completely artificial manner, taking place within the real environment ([Coen et al., 2019](#)). What sets AR apart is that virtual objects are overlaid onto real ones, seamlessly integrating them into the context of the physical world. By superimposing digital information onto existing information, the realness of the physical world is expanded, creating an enhanced perception for the user. AR applications utilize a technique called Simultaneous Localization and Mapping (SLAM) to determine the position and orientation of the rendering device relative to the surroundings. To determine the position and orientation of an object within its environment, a combination of sensor-based techniques (such as accelerometers and gyroscopes) and vision-based techniques (involving cameras, depth sensors, and artificial intelligence for recognizing visual markers or mapping and learning objects and the surrounding area) are often employed ([Coen et al., 2019](#)). Furthermore, certain AR systems take advantage of Bluetooth markers, Wi-Fi signal triangulation, and GPS data to accurately locate the rendering device within a given context. In this regard, [Coen et al. \(2019\)](#) found that the use of mobile technology (Augmented Reality) has positive consequences for both individual users in terms of improvement of SBs in seven different domains (cost of having single/double glazed windows, electricity consumption, washing machine water temperature, CO₂ emissions, LED/traditional incandescent light bulbs, shower water conservation, insulation vs. no insulation) and increase of environmental awareness.

3.3.3 Gamification

Gamification is an emerging field that aims to capture attention and engage people in sustainability topics. While the definition of gamification is still evolving ([Seaborn and Fels, 2015](#)), it generally refers to the integration of game design elements, such as points, leaderboards, levels, narrative, or time constraints, into non-game contexts, beyond mere entertainment purposes. The power of gamification lies in its ability to motivate players and create emotional connections within a gamified setting, whether the topics are for pleasure, education, or of societal importance. Gamification encompasses serious games and geo-games [Dicheva et al. 2015](#). Serious games are designed with a purpose that extends beyond pure entertainment and aims to influence thoughts and actions in real-life situations (see [Table 3](#)).

Sustainability is one area where serious games are widely applied, with goals including raising awareness of sustainability challenges, imparting knowledge and understanding, and encouraging players to develop environmentally and socio-economically harmonized solutions ([Ouariachi et al., 2019](#)). For instance, two different serious

TABLE 3 Studies based on Gamification technologies.

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome measures	Moderators	Results	Intention/ Behavior
21	Martínez-Borreguero et al. (2020)	N Students = 81 (aged 14–16)	Sustainability	Quasi-experimental type: within subject design (pre-test, post-test) and between subject design: Didactic interventions: 1. WebQuest ($N=28$), 2. Game about climate change ($n=27$), 3. Game about electricity ($N=26$)	Didactic ICT interventions: Web-Quest and Serious Games	1. Knowledge 2. Environmental Behavior 3. Environmental Attitude	/	+ The block with the greatest group progress was that of sustainability, followed by the ones on renewables and saving measures. + All the groups obtained an improvement from pre-test to post-test in terms of the level of knowledge in the sustainability block. Likewise, an improvement was also observed, although to a lesser extent than in the previous case, in relation to the block on renewable energies (group B obtained the better score). Finally, concerning the block of savings measures, it can once again be seen that it was group B that improved its level of knowledge the most. + The use of ICT-based active methodologies promotes environmental behavior in students. = The intervention has produced any change in the environmental attitude of the students.	Behavioral Intention
22	Moore and Yang (2020)	1. N Participants = 61 (N females = 36, N males = 25, M Age = 20.28, sd = 1.72); 2. N on-line participants = 293 (N females = 128, N males = 165, M Age = 38.83, sd = 11.19)	Environmental Communication	Experimental (within/between subject design): 1. Serious game vs. Trailer of the game vs. control; 2. Trailer vs. Control	Serious game/single- or multi-player	1. Eco-guilt, pro-environmental choice, intention toward future environmental behavior, two different observed behaviors (e.g., water bottle choice) 2. Eco-guilt, pro-environmental choice, intention toward future environmental behavior	(a) Environmental Attitude, (b) Trait Empathy in both studies	Study 1: + increase of one observed pro-environmental behavior (i.e., refusal of not re-usable water bottle and so not sustainable) in the trailer condition; Study 2: greater intention to engage in future environmental behaviors only for the ones in the trailer condition with lower levels of Environmental Attitude (moderation effect).	Behavior & Behavioral Intention

(Continued)

TABLE 3 (Continued)

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome measures	Moderators	Results	Intention/Behavior
23	Reihana et al. (2019)	N = 8, aged 12–16	New Zealand Journal of Ecology	Within subject design (pre-post)	Serious Game: Eko.	1. Eco-literacy 2. Indigenous knowledge	/	+ 65% of the students reported some degree of knowledge acquisition, with 28% citing no recall, and 35% recalling at least 3 species from the potential 15 species which they were exposed to.	Behavioral Intention
24	Casals et al. (2020)	N social houses with monitoring system deployed = 88	Energy and Buildings	Between Subject designs: Experimental (n = 44) and Control (n = 44); Within subjects design: pre-post	Serious game and metering system	1. Energy consumption 2. Energy consumption behavior and energy awareness 3. Peak demand 4. Social media activity and energy knowledge sharing 5. IT literacy	/	+ The intervention increased social housing tenants' awareness and engagement in certain energy saving behavior and provided an average electricity saving of 3.46% and an average gas saving of 7.48%. Although savings were found not to be statistically significant, an effect size was detected (0.2).	Behavior
25	Schaal et al., 2018	N students = 206 (52.9% females; M age = 13.7, sd = 2.3)	International Journal of Science Education, Part B	Quasi experimental design; within subject (pre-post)	Geogame for experiential outdoor learning	1. Attitudes toward nature 2. Biodiversity-related knowledge	/	+ Game-related enjoyment increased positive attitudes toward nature.- game-related enjoyment did not increase biodiversity-related knowledge	Behavioral Intention

games were developed in an experimental lab study for designing and validating ICT-based learning interventions for sustainability content (Martínez-Borreguero et al., 2020). During the study, participants were exposed to three different experimental conditions: a Webquest and two distinct serious games. In one experimental group, the serious game “My Green Energy Planet” was utilized, an online video game focused on climate change. In this game, participants were tasked with managing a city by implementing energy-saving measures, utilizing renewable energy production plants, and avoiding non-renewable energy plants.

Another serious game called “Control of the Spanish Network,” developed by the institution Red Eléctrica de España, was employed in the study. The results indicated that all groups showed improvement in knowledge related to sustainability from the pre-test to the post-test. The overall utilization of active ICT-based methodologies effectively promoted environmental behavior among the students. However, the intervention did not result in any change in the environmental attitudes of the students. In a separate study, Moore and Yang (2020) utilized a serious game named Eco, which could be played both online and offline, either as a single-player or multiplayer game (Strange Loop Games, 2015). Eco provides a collaborative space where players work together to save the world from an impending meteor while simultaneously maintaining the ecosystem. What sets Eco apart from other open-world games is its unique feature of resource depletion. Unlike games that require players to hunt endlessly for survival, Eco introduces the concept of resource balance, where overhunting and other activities can potentially lead to the extinction of resources, such as driving the deer population to extinction. The effectiveness of Eco was evaluated in two separate studies. In the first study, Eco was compared to a video of the game or a trailer, as well as a control condition. Only the trailer condition showed an increase in observed pro-environmental behavior, such as using reusable water bottles. In the second study, no significant differences were found between the video condition and the control condition. Moore and Yang (2020) also examined the moderating role of environmental attitude in the relationship between experimental conditions and behavioral intention. It was discovered that individuals with lower levels of positive environmental attitude exhibited a greater intention to engage in future environmental behaviors when exposed to the video condition or the game trailer.

A further similar serious game called Eko was employed in a field experiment conducted in New Zealand (Reihana et al., 2019). By incorporating fundamental ecological concepts with indigenous Maori knowledge, the game successfully fostered eco-literacy, indigenous knowledge, and pro-environmental behaviors. Among the participants, 65% reported some level of knowledge acquisition, with 28% indicating no recall, and 35% recalling at least 3 out of the 15 species they were exposed to. Another serious game was developed to encourage energy efficiency and reduce carbon emissions among social housing tenants (Casals et al., 2020). The game underwent validation in a sample of European social housing units using a two-stage experimental design that incorporated pre-post and control group approaches. The game's protagonist is the Energy Cat, controlled by the player, who resides in a house with human characters controlled by artificial intelligence. The Energy Cat strives to live in a comfortable and energy-efficient house, guiding the human characters to modify their energy-consuming behavior. The serious game proved effective in enhancing social tenants' understanding and involvement in energy

efficiency, resulting in an average electricity saving of 3.46% and an average gas saving of 7.48%.

Regarding geo-games, they encompass location-based and location-dependent games (Schaal et al., 2018) that require players to engage in activities and movement in real-world settings. These games often incorporate narratives and game characters to create an immersive experience. Smartphones, commonly used for geo-games, provide unique capabilities for game tasks and location-based learning. The integrated camera, microphone, texting, and video features of smartphones can be utilized to provide necessary information within the game or to document observations and answers. Additionally, GPS and integrated map services enable the planning of guided tours (Horton et al., 2013). As a result, geo-games offer extensive opportunities for environmental education and the promotion of sustainable behaviors. Schaal et al. (2018) developed a geo-game that aimed to create sensory experiences and foster appreciation for biodiversity through mobile technology. The results indicated that game-related enjoyment led to more positive attitudes toward nature, although it did not significantly increase biodiversity-related knowledge.

3.3.4 Persuasive apps

As computing technology gets more powerful and transportable, it becomes more and more integrated into people's everyday lives and influences their behavior. Technology may be created specifically to influence behavior and, in this vein, it has been referred to as “persuasive technology” (Filippou et al., 2015; see Table 4).

Mahmud et al. (2020) provides an example of the usage of persuasive applications. An online gamified mobile application called JouleBug was utilized in this study to motivate students to improve their sustainability practices through pro-environmental behaviors. JouleBug is a smartphone application with an environmental theme that blends mobile games, social networking, and educational tools to establish and sustain daily habits in environmental education (Mahmud et al., 2020). The Authors conducted a study using a quasi-experimental design and both qualitative and quantitative methods on 48 students, 28 of whom were in the treatment group and 20 were in the control group. The results showed that the treatment group performed significantly better than the control group in the following areas: sustainability knowledge and pro-environmental behavior. Another persuasive gamified application, named EcoIsland, was developed to encourage users to reduce CO₂ emissions (Kimura and Nakajima, 2011). EcoIsland was designed to be installed in the living room or another prominent place in a household. Kimura and Nakajima (2011) found that the majority of participants stated they were more environmentally concerned after the experiment than before. In contrast, there was no significant correlation with reported activities in the data on air heater electricity use.

Another gamified mobile application was connected to a household's smart meter to foster a behavioral change in terms of household electricity consumption reduction (Wemyss et al., 2019). In particular, the intervention was designed to activate social norms and improve electricity consumption behavior in neighborhood households. After a three-month intervention, a significant improvement was seen in electricity savings but 1 year later, the survey showed a relapse effect, and the beneficial effects were minimal. There was no difference in short- and long-term results between the two

TABLE 4 Studies based on persuasive apps.

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome measures	Moderators	Results	Intention/ Behavior
26	Mahmud et al. (2020)	N Students = 48	Sustainability	Quantitative/Qualitative study, Quasi-experimental design (N treatment group = 28, N control group = 20)	Online gamification activities	1. Sustainability knowledge 2. Pro-environmental behavior 3. Recognition by the teacher and peers 4. Competition 5. Sense of belonging to a group 6. Time constraint 7. Boredom	/	+ The treatment group showed, at post-test, a statistically significant difference from the control group in the following factors: sustainability knowledge and pro-environmental behavior. + In JouleBug mean points, the treatment group showed a statistically significant difference from the control group. + The following factors were identified by the focus group: Recognition by the teacher and peers, Competition and Sense of belonging to a group. - Similarly, the focus group showed: Time constraint and Boredom.	Behavior
27	Kimura and Nakajima (2011)	N Families = 6, N Participants = 20 (N females = 8, N males = 12, aged 15–58)	PsychNology Journal	Longitudinal study (4 weeks) 1. Measurement of ordinary energy consumption before installation of EcoIsland 2. EcoIsland installation and it was requested that only one member of the household use it 3. All family members used EcoIsland 4. All family members used EcoIsland that contains emission- trading system between families.	Persuasive application	1. Environmental ecology awareness 2. Communication within family 3. Cooperation with other participants 4. Competition between participants	/	+ In the survey, 17 out of 20 participants said that they were more conscious of environmental ecology after the experiment than before. - From the air heater electricity usage data, there was no significant correlation with the reported activities.	Behavioral Intention
28	Wemyss et al. (2019)	N households = 82	Energy Research & Social Science	Experimental design 2 (location: city 1 vs. city 2) x 3 (gamified structure: competitive vs. collaborative vs. control)	Gamified mobile application	1. Improve electricity consumption behavior 2. Social norms	/	+ A considerable improvement in electricity savings was reported following the three-month intervention- However, one year later, a spillover effect developed, and the beneficial effects were minimal. There was no difference in short- and long-term results between the two separate gamified approaches, competitive group and collaborative group.	Behavior

(Continued)

TABLE 4 (Continued)

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome measures	Moderators	Results	Intention/ Behavior
29	Oppong-Tawiah et al. (2020)	N Participants = 137	Journal of Business Research	Within-subjects (repeated measures) experiment. The Authors iteratively developed a system, evaluating it in each design cycle (5) including a longitudinal evaluation of PEB (pro-environmental behaviors)	Power-metering, Energy metering sub-system (computer), eco-feedback through virtualized ecological system (garden): mobile application	1. Reduction in electricity consumption 2. Motivation in implementing pro-environmental behaviors	/	+ Results showed a reduction in electricity consumption and an increase in motivation to continue engaging in pro-environmental behaviors.	Behavior
30	Won (2018)	1. N participants = 57 (N females = 20, N males = 37); 2. N Participants = 400	Archives of Design Research	Experimental mixed (within-between) Design. 3 treatment conditions (1. Emotional support = Attitude toward Behavior (AB) vs. Subjective Norm (SN) vs. Perceived Behavioral Control (PBC) vs. Behavioral Intention 2. Ability support = AB vs. SN vs. PBC vs. Behavioral Intention 3. Social learning support = AB vs. SN vs. PBC vs. Behavioral Intention) and 1 control (Baseline = AB vs. SN vs. PBC vs. Behavioral Intention)	Applying PSPB (Persuasive Service design strategies based on TPB - 'Theory of Planned Behavior') design concepts in the development of mobile applications	1. Attitude toward Behavior 2. Subjective Norm 3. Perceived Behavioral Control 4. Behavioral Intention	/	+ According to social learning support and ability support goals, all three techniques reduced the users' negative emotions in comparison to the control group and enhanced perceived behavior control and subjective norm (SN).	Behavioral Intention
31	Oliveira et al. (2016)	N Participants = 12 (N females = 4, N males = 8, aged 18–22)	Computers in Human Behavior	Within-subjects design AB-BA (Step 1: group A control group and group B intervention group; Step 2: group B control group and group A intervention group)	Persuasive smartphone application	1. Promotion of sustainable behaviors 2. Promotion of energy conservation	/	+ Participants in all experimental conditions had an increased likelihood to follow the procedures necessary to consume less energy compared to a control condition.	Behavioral Intention

separate gamified approaches, the competitive group, and the collaborative group (Wemyss et al., 2019). In the work environment field, Oppong-Tawiah et al. (2020) created a gamified mobile application to promote sustainable energy use in the office. They used five design cycles to develop and test a system that tracks employees' electricity usage on their computer-related equipment, engages them through the app using the metaphor of a garden (employees saw in the app a garden that flourished when they conserved electricity), and encourages them to do so. The outcomes of the design cycles reinforced one another, showing how the system lowers employees' power use and boosts their desire to keep up their pro-environmental behavior.

A further example of a persuasive app is proposed by Won (2018) and was focused on the role of socio-emotional learning and ability support. The results of this research, in which 400 participants were divided equally into four groups including one control group, showed that all three strategies reduced the users' negative emotions in comparison to the control group and enhanced perceived behavior control, and subjective norm (Won, 2018). Another study conducted with the use of persuasive apps to modify how time appears, i.e., a lowering of time perception, was aimed at reducing excessive energy use (Oliveira et al., 2016). In comparison to a control group, participants claimed that the app increased their likelihood of following the procedures necessary to consume less energy (*ibidem*).

3.3.5 Other categories of digital technologies

Those digital technologies less used in the selected studies are reported in the following lines (See Table 5).

3.3.5.1 Eco-driving assistance devices

Eco-driving assistance devices aim to reduce CO₂ emissions by promoting an eco-driving style, which is estimated to result in a fuel consumption reduction of 10 to 30% (Sivak and Schoettle, 2012). To assist drivers in adopting and maintaining eco-driving practices, eco-driving assistance systems (EDAS/EDSS) have been introduced in new vehicles. These systems provide support interventions and feedback to drivers (Ruscio et al., 2018). The effectiveness of eco-driving devices relies on the assumption that the introduction of assisting technology will encourage changes in driving behavior, including smooth accelerations, steady speed, early gear changes, efficient deceleration, and moderate brake usage. In a study conducted by Ruscio et al. (2018) using a virtual driving simulator, the first-time use of eco-driving assistance technology was evaluated in terms of its impact on CO₂ reduction. The study recorded actual driving parameters and CO₂ emissions, comparing them to the optimal eco-driving style. Results showed that the initial exposure to eco-driving technology led to a reduction in cumulative fuel consumption, primarily attributed to speed reduction. However, the overall CO₂ emissions of the experimental group did not differ significantly from the control group.

3.3.5.2 Videos administered on-line

Harmon and Gauvain (2019) explored the effects of online videos on water conservation behaviors. Participants viewed two brief videos—one focused on the global scarcity of water and the other highlighting disgusted reactions to certain conservation methods. While the study found a small positive increase in willingness to adopt

pro-conservation water usage and behavioral intention to use recycled water, the media messages did not have a significant impact on actual behaviors, such as accepting bottled recycled water or supporting recycled water initiatives. These findings underscored the need for additional interventions beyond web-based videos to effectively promote pro-conservation behaviors.

3.3.5.3 Computer-based concept mapping

Another approach, computer-based concept mapping, involves creating visual representations of an individual's knowledge structure in a specific domain. Eggert et al. (2017) utilized a concept mapping tool adapted for an experimental manipulation aimed at increasing climate change knowledge. The study divided participants into four experimental conditions centered around climate change themes. Providing students with relevant concepts supported them in generating high-quality concept maps related to climate change conceptual knowledge. However, excessive scaffolding and support had the opposite effect. Students who received argumentative relations were able to visualize their argumentation process regarding climate change solutions. Meanwhile, students in the free mapping condition also demonstrated success in producing high-quality concept maps.

3.3.5.4 Robots

Ham and Midden (2014) researched the persuasive effects of social feedback delivered by a robotic agent. In two experiments, participants were given the task of carrying out washing tasks on a simulated washing machine while having the opportunity to save energy. The social feedback conditions, represented by an iCat—a stylized head of a cat capable of expressing social expressions through movement and speech—were placed on the participants' desks. Study 1 demonstrated that both social feedback conditions had a significant impact on reducing electricity consumption compared to the control condition, which provided factual feedback about electricity consumption. Negative verbal reactions from a domestic robot were particularly effective in influencing behavior. Study 2 also investigated the influence of task similarity and found that the persuasive effects of negative feedback were enhanced when the tasks were similar.

3.3.5.5 Online tools

Spence et al. (2014) utilized an online tool in a simulation scenario where participants, specifically undergraduates, were presented with an energy display showing their energy use in terms of kilowatt-hour carbon dioxide (CO₂) emissions, costs, and energy units (kWh). The study found that framing energy reduction in terms of CO₂ emissions increased the salience of climate change, which, in turn, increased participants' intentions to engage in environmental behavior. While financial costs may be a more tangible outcome of energy reduction for many individuals, the study emphasized the importance of environmental motivation in driving environmental behavior beyond energy-related actions. In a study by Wheaton et al. (2016), aimed at promoting pro-environmental behaviors (PEBs) after a nature-based tourism intervention, such as a guided tour, it was found that although the intervention had limited overall influence on conservation actions, it was effective in stimulating social media-related actions. Post-tour conservation actions were

TABLE 5 Studies based on other categories of digital technologies.

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome measures	Moderators	Results	Intention/ Behavior
32	Ruscio et al. (2018)	N male drivers = 24 (<i>M</i> age = 22.2, <i>sd</i> = 3.2)	International Journal of Industrial Economics	Between groups design: eco-driving training (<i>n</i> = 12) vs. control (<i>n</i> = 12)	Eco-driving assisting device or EDA	1. Driver's Behavior 2. Driver's Acceptance 3. Driver's workload	/	+The experimental group and the control group presented different values of speed profile, with the experimental group keeping a slower speed. = No significant differences emerged in the number of gear changes, in the mean time spent for each of the gears, not for the fuel efficiency and the related CO ₂ emissions. = No significant differences emerged in driver's acceptance and attitudes toward eco-driving.	Behavior
33	Harmon and Gauvain (2019)	1. <i>N</i> students = 143 (65% females; aged 18–21; <i>M</i> age = 19.44, <i>sd</i> = 0.95). 2. <i>N</i> participants = 591 (aged 18.76; median age = 25–34); 3. <i>N</i> students = 152 (75% females; <i>M</i> age = 19.13, <i>sd</i> = 1.69)	Basic and Applied Social Psychology	1. Experimental between subject design: a. pro-environmental video (<i>n</i> = 72) b. neutral video (<i>n</i> = 71). 2. Experimental design between subject design: a. pro-environmental video b. neutral video c. reducing disgust video 3. Experimental design between subject design: a. pro-environmental video (<i>n</i> = 72) b. neutral video (<i>n</i> = 71) c. reducing disgust video.	Videos administered via Internet	(1) a. Water use behaviors, b. Water Attitudes, c. Misinformation, d. Ignorance, e. Social Norms, f. Disgust Sensitivity and g. Environmental Concern; (2) a. Disgust Sensitivity, b. Pro-environmental behavior, c. Willingness to use recycled water. (3) a. Behavioral Intention, b. Behavioral Measures: drinking a bottle of recycled water and signing a petition about the use of recycled water.	/	Study 1. - Viewing a fact-based video about water as a limited resource didn't increase participants' willingness to endorse sustainable water use. = Rates were similar in the treatment and control groups in the Water Attitudes Survey. Study 2. + Viewing Internet video messages about either disgust reactions or water scarcity has a small but unsubstantial effect on people's willingness to use recycled water. Study 3. + Participants in both experimental conditions reported greater behavioral intention to use recycled water. = Viewing pro-conservation videos did not affect actual pro-conservation behaviors. Participants accepted bottled recycled water and signed the recycled-water petition at similar rates.	Behavioral Intention
34	Eggert et al. (2017)	<i>N</i> students = 158 students (<i>N</i> females = 107, <i>N</i> males = 47 and 4 students who did not specify their gender; <i>M</i> age = 17.16)	Research in Science Education	Experimental between subject design: Themes about climate change: 1. Map-generation condition (<i>n</i> = 38), 2. Concepts-provided condition (<i>n</i> = 37), 3. Lines provided condition (<i>n</i> = 41), 4. Concept and lines provided condition (<i>n</i> = 42). Within subject design: pre-post.	Computer-based learning environment	1. Knowledge about the issue of climate change 2. Argumentation processes about possible solution strategies to tackle climate change. 3. Reasoning and decision making on socioscientific issues in general.	/	= Increase in students' competence in the posttest for all four treatment conditions. Thus, all students benefitted from the teaching intervention in a similar way in terms of knowledge gains. = Regarding socio-scientific reasoning, students in all four treatment conditions improved on the posttest scores. No differential effects for the different treatment conditions could be found. = Students in all treatment conditions improved in a similar way with respect to learning outcomes for "developing solutions."	Behavioral Intention

(Continued)

TABLE 5 (Continued)

	Authors	Sample	Journal title	Experimental design	Technology type	Outcome measures	Moderators	Results	Intention/ Behavior
35	Ham and Midden (2014)	1. <i>N</i> students = 33 (<i>N</i> females = 6, <i>N</i> males = 27, aged 18–40); 2. <i>N</i> students = 120 (<i>N</i> females = 48, <i>N</i> males = 72, aged 18–40)	International Journal of Social Robotics	1. Experimental between subject design: a. factual feedback condition, b. high-agency social feedback condition, and c. low-agency social feedback condition. 2. 2 (task similarity: low vs. high) × 2 (feedback type: negative vs. positive) mixed model experimental design.	Human–robot interaction	1. Electricity Consumption Score (for both studies)	/	Study 1.+ Both social feedback conditions had the strongest influence on electricity consumption reduction behavior, compared to the control condition, i.e., a factual feedback about electricity consumption. The strongest effects were obtained especially with negative (vs positive) verbal reactions by a domestic robot. Study 2.+ Task similarity increased the persuasive effects of negative feedback.	Behavior
36	Spence et al. (2014)	1. <i>N</i> Participants = 153 (<i>N</i> females = 69, <i>N</i> males = 84; aged 17–36, median age = 20). 2. <i>N</i> Students = 102 (86 females, 16 males; aged 18–21, median = 18)	Journal of Environmental Psychology	1. Between Subject Experimental Design: a. Energy (<i>n</i> = 64), b. Cost (<i>n</i> = 50) and c.CO ₂ (<i>n</i> = 56) Home Energy Calculator conditions. 2. Between Subject Experimental Design: a. Energy (<i>n</i> = 35), b. Cost (<i>n</i> = 32) and c.CO ₂ (<i>n</i> = 35) Home Energy Calculator conditions.	Online Home Energy Calculator	1. a) Social Values, b) Environmental Behavior (donations to a Charity for climate change). 2. a) Interest in reducing energy use, b) Psychological distance of climate change, c) Salience of climate change, d) Salience of financial issues, e) Environmental Behavior (donations to a Charity for climate change), f) Behavioral intention	/	Study 1.= The HEC calculator condition did not significantly affect measures of Social Values between time points. + CO ₂ and cost conditions differed from one another with the first one being significantly higher, but = comparisons of CO ₂ and energy conditions and energy and cost conditions were non-significant. Study 2.+ Climate change salience was significantly higher in the CO ₂ HEC condition, compared with energy and cost conditions, while the energy and cost conditions did not differ significantly. = Amounts of charity donations and behavioral intention did not differ significantly across conditions.	Behavioral Intention
37	Wheaton et al. (2016)	<i>N</i> visitors completed pre-tour and post-tour surveys = 362, <i>N</i> visitors completing a final survey three months after the tour = 94	Journal of Sustainable Tourism	Quasi-experimental, longitudinal	Technology-based behavioral messaging	1. Promotion of sustainable behaviors 2. Connectedness to nature 3. Environmental attitudes and self-efficacy 4. Commitment to take action	/	The results showed that = although the intervention had little influence on conservation action overall,+ it was effective for a social media-related action. + Post-tour conservation actions were significantly affected by emotional connection to wildlife during the tour and repeat visitation to either the same or another state park. + Visitors' connectedness to nature increased during the three-hour tour, but - returned to pre-visit levels three months later.	Behavior

significantly influenced by participants' emotional connection to wildlife during the tour and their repeat visitation to either the same or another state park. Additionally, visitors' connectedness to nature increased during the three-hour tour but returned to pre-visit levels 3 months later, suggesting the need for more sustainable and long-lasting interventions.

3.4 RQ 4: sustainable behaviors

Most published articles aimed to promote different types of sustainable behaviors: energy and water saving (56.75%), reducing environmental pollution (27.03%), reducing CO₂ emissions (5.40%), fund-raising (5.40%) and eco-literacy (5.40%). In the following paragraphs, evidence that emerged for each sustainable behavior is addressed (Figure 7).

3.4.1 Energy and water savings

This category refers to water and energy conservation, or rather, the reduction of such resource waste. To contain the wastefulness of water and energy, the persuasive effect of different types of technologies on these pro-environmental actions was investigated, showing their relevant impact. In particular, the effectiveness of various strategies for promoting pro-environmental behavior includes the combination of a robotic agent and social feedback (Ham and Midden, 2014), the use of vivid and personalized interventions (Bailey et al., 2015), and the utilization of social messages through immersive virtual environment technology (Khashe et al., 2019). Additionally, gamification (Casals et al., 2020; Mahmud et al., 2020), mobile applications (Oliveira et al., 2016), and eco-feedback technologies that provide real-time energy use information (Schwartz et al., 2015; Asensio and Delmas, 2016; Chiu

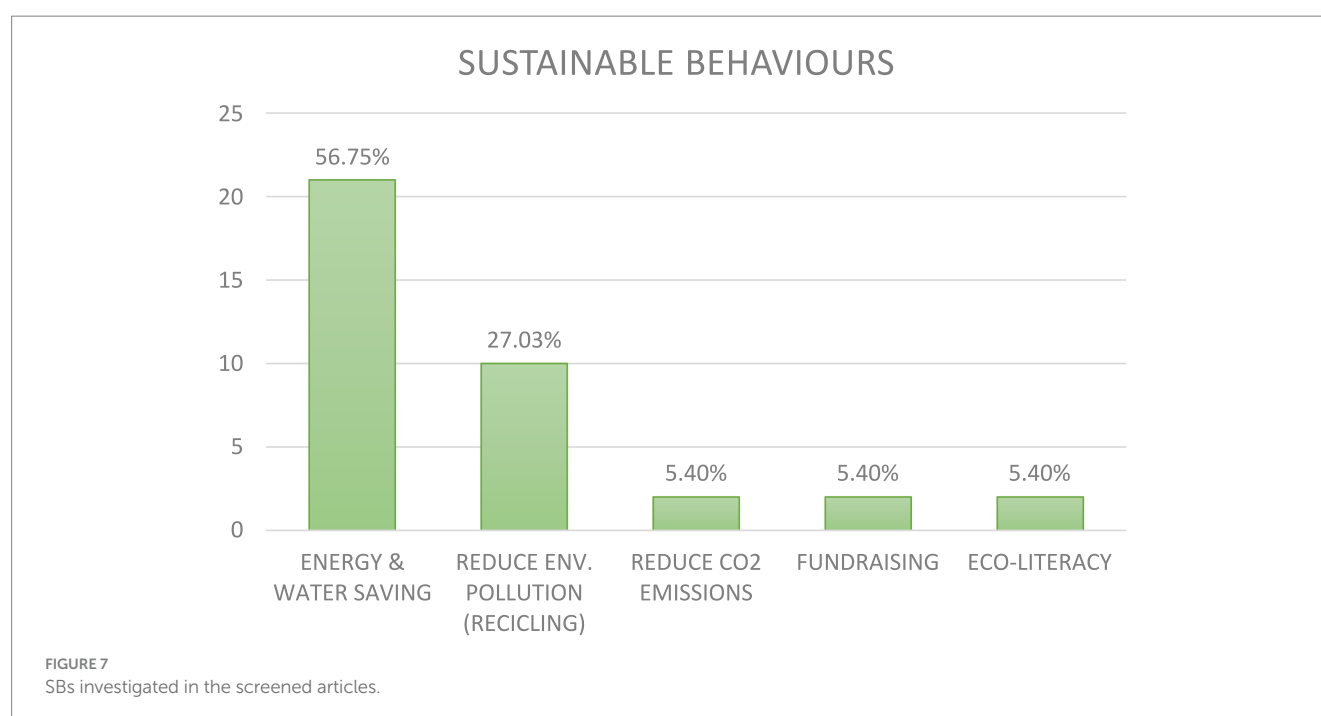
et al., 2020) have been examined in various studies. These interventions have been explored in different contexts, including situations where individuals are not financially responsible for energy costs, such as hotels (Tiefenbeck et al., 2019). However, the long-term impact may not support the maintenance of the positive results achieved during the intervention (Wemyss et al., 2019); indeed, 1 year after using the app, the energy savings were not confirmed.

3.4.2 Reducing environmental pollution

As concerns the actions aimed at the reuse of materials, research has highlighted the complexity of this type of sustainable behavior in changing habits, due to the request of a significant effort from people (von Borgstede and Biel, 2002). Thus, virtual reality has been used to explore its persuasive role in enhancing recycling actions (Chirico et al., 2021), whereas Mozo-Reyes et al. (2016) tested if eco-feedback may influence triggering conservation actions. Results showed that eco-feedback technology increases the reuse activity outside the home. Nevertheless, Schultz and Oskamp (1996) emphasized the cognitive and physical challenges associated with recycling, as individuals must make decisions about what items to recycle.

3.4.3 Reducing CO₂ emissions

In the context of reducing CO₂ emissions, transportation plays a significant role in urban air pollution and climate change (Ruscio et al., 2018). Numerous studies have focused on finding effective persuasive strategies to encourage sustainable actions and decrease pollution for the benefit of the environment and human health (Ettema et al., 2016). Technological applications have been identified as valuable tools in promoting eco-friendly activities for reducing CO₂ emissions (Kimura and Nakajima, 2011).



3.4.4 Eco-literacy

Ecological literacy refers to the knowledge and ability to utilize information related to ecology and sustainability when making decisions. While it is acknowledged that knowledge alone does not guarantee pro-environmental behavior (Skamp et al., 2013), understanding environmental issues is a crucial prerequisite for changing attitudes and intentions to act. Eggert et al. (2017) demonstrated that computer-based concept mapping aids individuals in visualizing and organizing their knowledge, facilitating learning about environmental topics like climate change and aspects of socio-scientific reasoning and decision-making. On the other hand, Schaal et al. (2018) investigated the relationship between geo-games and biodiversity knowledge and found that game-related enjoyment did not predict biodiversity knowledge. However, the study also revealed that game-related enjoyment was a strong predictor of attitudes toward nature.

3.4.5 Fundraising

This type of behavior refers to the act of gathering voluntary contributions such as money or other resources. Non-profit organizations are progressively promoting their causes using technologies (Janpol and Dilts, 2016) and they report increased donations when virtual reality is used. Thus, it appears that technologies can both increase empathy and influence people toward pro-environmental behavior. Nelson et al. (2020) confirmed that virtual reality is an effective way to raise awareness of environmental problems and encourage pro-environmental actions.

4 Duration and follow-up

Most published articles did not report the duration of the study (62.50%). Laboratory experiments had a duration of 2 h (Schaal et al., 2018), 90 min sessions repeated four times (Eggert et al., 2017), and 30 min (Harmon and Gauvain, 2019). Studies belonging to the category of power-metering systems reported longer interventions with different durations: 2 months (Tiefenbeck et al., 2019), 18 months (Schwartz et al., 2015), 4 months (Wemyss et al., 2019) 4 years (Henn et al., 2019). Only three studies in the systematic evidence map included a follow-up assessment. One study conducted a follow-up after 8 weeks (Mahmud et al., 2020). Another study (Wemyss et al., 2019) provided results 1 year later, serving as a follow-up to a behavior change intervention named Social Power. This intervention aimed to reduce household electricity consumption by utilizing a gamified mobile application connected to the household's smart meter. Lastly, in a study by Mahood et al. (2014), a follow-up assessment was conducted 2 weeks after the interventions. In this study, participants in the experimental group received the first message prompting them to take their selected action, followed by up to three additional prompts spaced 1 week apart.

5 Population involved

Regarding the population involved, it was found that over 40% of the studies included in the systematic evidence map focused on students. (43.24%) or civil society in general (8.11%), for experimental studies. Studies involving interventions with power-metering systems

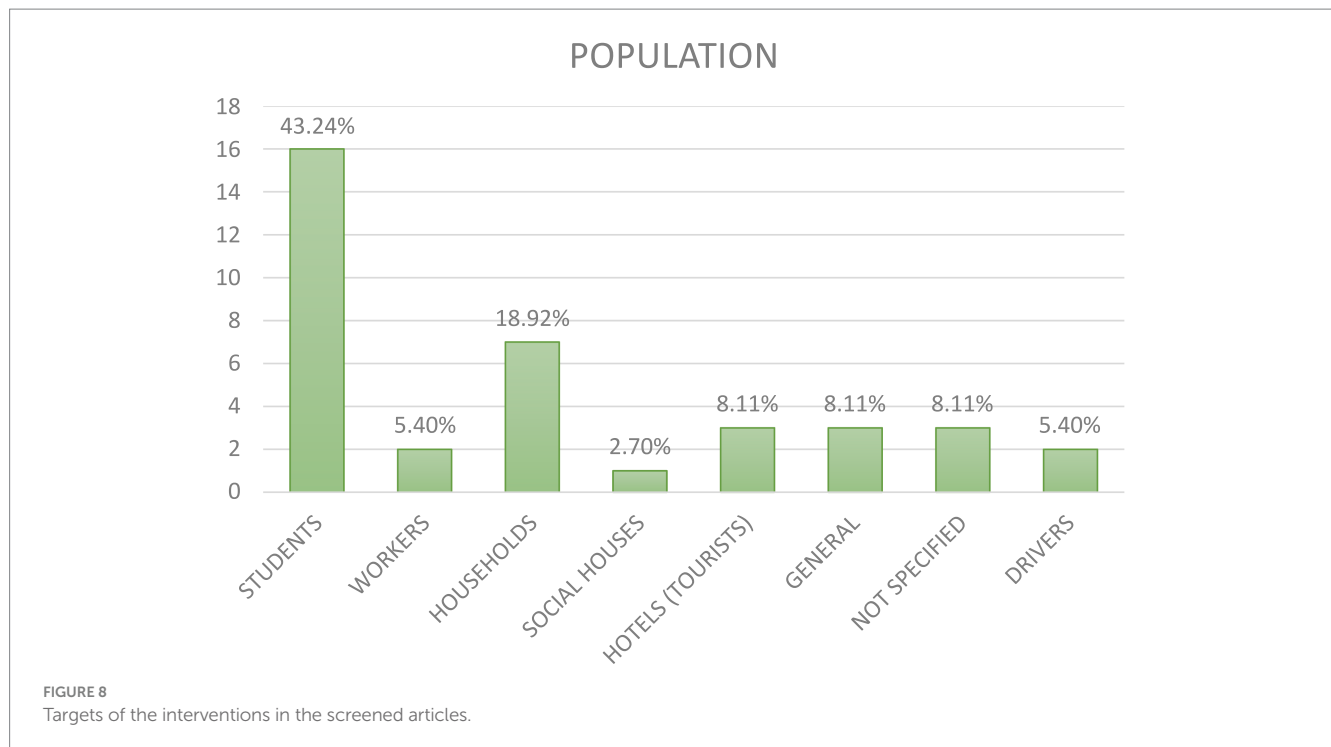
targeted inhabitants of social houses (2.70%), inhabitants of different households (18.92%), hotels' tourists and visitors (8.11%), or workers from offices (5.40%), and only one study employed young drivers (5.40%). In three studies (8.11%) characteristics of the sample were not specified (Figure 8).

6 Conclusion

In this systematic mapping, we reviewed 37 articles on digital interventions to determine their effectiveness in promoting SBs outcomes, the type of interventions used, and the type of targeted SBs that have been investigated.

All 37 studies showed at least one positive result (100%); of these, 18 (48.65%) showed only positive outcomes (2, 3, 5, 6, 7, 8, 9, 10, 11, 18, 19, 22, 23, 24, 29, 30, 31, 35), and 19 (51.35%) displayed a mix of positive and negative results (1, 4, 12, 13, 14, 15, 16, 17, 20, 21, 25, 26, 27, 28, 32, 33, 34, 36, 37). Generally, the following factors showed the most successful outcomes: decrease in consumption (37.84%; 1, 2, 3, 6, 7, 8, 14, 19, 24, 28, 29, 31, 33, 35), increase in pro-environmental behaviors/intention to perform pro-environmental behaviors (32.43%; 4, 9, 10, 11, 13, 17, 18, 20, 22, 25, 26, 29), and increase in pro-environmental knowledge/awareness (16.22%; 19, 21, 23, 26, 27, 34).

Of course, publication bias (i.e., primarily positive studies getting published) has to be considered as one of the common confounding factors that could limit the generalizability of this systematic mapping over time. Another issue to be considered is the attitude-behavior gap, with an increasing number of findings confirming this phenomenon substantiated by several methodological flaws (e.g., social desirability bias), contextual (e.g., time pressure and constraints) and/or individual issues (e.g., inability to answer) (Caruana et al., 2016) that influence the existence of such a gap and its magnitude. These issues can be partially overcome by measuring behavior more objectively, for example, by relying on behavioral data, as shown in our section about power-metering systems (e.g., Henn et al., 2019), field experiments with actual behavior as an outcome (e.g., Tiefenbeck et al., 2019). Unobtrusive objective measurement can be applied to several domains: driving behavior can be measured using eco-driving assisting devices coupled with odometers (Ruscio et al., 2018) or GPS devices, energy consumption can be monitored digital meters (Henn et al., 2019) and this can be applied also to water conservation (i.e., smart-show meters), and food waste can be weighed and photographed (Cropley et al., 2022). Enhancing the collection of data on naturally occurring behaviors might increase the chance to collaborate with several non-governative organizations, industrial partners, or public institutions (Lange et al., 2023). Such collaborations have provided results that sometimes are in strong contrast with the ones derived from self-reports (Berger et al., 2022) or that can provide a more strong scientific basis for the behavioral feasibility of technological innovations. Notwithstanding these limitations, due to these positive initial results, it is essential to ensure equity in terms of access to digital tools and at the same time spread digital literacy across all groups in society, in terms of upskilling and reskilling of people. This is particularly needed in today's era, where digital media has become pervasive, the widespread use of computers, tablets, and smartphones has led to an unprecedented number of internet users (Murthy, 2013). This trend has been further amplified



during the recent Covid-19 pandemic, where the necessity of virtual connectedness due to the global crisis has shifted our interactions from face-to-face to technology-based platforms, significantly impacting our lives. The advent of social media networks and digital economies has revolutionized traditional communication channels, reshaping the way we perceive human interaction.

In the realm of digital environmental research, development, and implementation, it is crucial to involve key stakeholders and end users from the early stages and maintain their continuous engagement throughout the design and evaluation of new technologies (Kok et al., 2017). Adopting human-centered design approaches can be instrumental in this process, emphasizing the importance of understanding and empathizing with end users, fostering transdisciplinary collaboration, and incorporating iterative feedback from users to create innovative solutions that are desirable, feasible, and viable (Asbjørnsen et al., 2022). Unfortunately, the reviewed digital interventions did not report best-practice activities and recommendations. On the whole, in contrast to the findings of De Salas et al. (2022) regarding gamified interventions, the studies included in this review offered valuable insights into the technical development practices of these interventions, providing detailed descriptions. Our systematic mapping review revealed the use of diverse data collection tools and measures to report the outcomes of interventions targeting various objectives. While this heterogeneity can be seen as advantageous in addressing the complexity of interventions to promote sustainable behaviors, it limited opportunities for direct comparisons.

In conclusion, our review of these 37 articles investigating pro-environment interventions highlighted that, despite the reported efficacy, the adoption of best-practice intervention designs, as outlined by De Salas et al. (2022) in the context of serious games, was not consistently evident in the studies covered in our mapping. The authors emphasized the importance of understanding existing behaviors,

employing best-practice technology development approaches such as multidisciplinary teams and user-centered design, and carefully considering the reasons behind intervention choices. Moreover, the lack of follow-up assessments post-intervention limited the understanding of long-term behavior change, as most studies focused on short-term engagement.

The outcomes of this set of studies do not provide a definitive understanding of which digital interventions are effective and the underlying reasons for their success or failure, indicating a need for further exploration in this field. Consequently, it is premature to offer specific recommendations to policymakers. However, for research funding agencies, we suggest directing resources toward more well-planned, well-executed, and focused studies in this area. To enhance the rigor of future research, several considerations should be addressed. We align with the recommendations of De Salas et al. (2022), advocating for detailed descriptions of intervention design characteristics and the rationale behind design choices, encompassing both behavioral and technological aspects. By doing so, future studies can significantly contribute to the successful adoption of digital interventions in promoting sustainable behavioral changes.

Author contributions

OM: research ideation, research methodology, design, data collection, data analysis, conceptual model, definitional advancement, and manuscript preparation. AM: data analysis, conceptual model, definitional advancement, and manuscript preparation. SM: data analysis and manuscript preparation. GV: research ideation, and supervision. FF: research ideation, research methodology, design, data collection, data analysis, conceptual model, definitional advancement, manuscript preparation, and

supervision. All authors contributed to the article and approved the submitted version.

Funding

The study was supported by PON “RICERCA E INNOVAZIONE” 2014–2020, EX D.M. n. 1062/21 DEL 10/08/2021.

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.

References

- Ahn, S. J. G., Bailenson, J. N., and Park, D. (2014). Short-and long-term effects of embodied experiences in immersive virtual environments on environmental locus of control and behavior. *Comput. Hum. Behav.* 39, 235–245. doi: 10.1016/j.chb.2014.07.025
- Ahn, S. J., Fox, J., Dale, K. R., and Avant, J. A. (2015). Framing virtual experiences: effects on environmental sustainability and behavior over time. *Commun. Res.* 42, 839–863. doi: 10.1177/0093650214534973
- Ajzen, I. (1991). The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50, 179–211. doi: 10.1016/0749-5978(91)90020-T
- Akande, A., Cabral, P., and Casteleyn, S. (2019). Assessing the gap between technology and the environmental sustainability of European cities. *Inf. Syst. Front.* 21, 581–604. doi: 10.1007/s10796-019-09903-3
- Andoni, M., Robu, V., Flynn, D., Abram, S., Geach, D., Jenkins, D., et al. (2019). Blockchain technology in the energy sector: a systematic review of challenges and opportunities. *Renew. Sust. Energ. Rev.* 100, 143–174. doi: 10.1016/j.rser.2018.10.014
- Asbjørnsen, R. A., Hjelmæsæth, J., Smedsrød, M. L., Wentzel, J., Ollivier, M., Clark, M. M., et al. (2022). Combining persuasive system design principles and behavior change techniques in digital interventions supporting long-term weight loss maintenance: design and development of eCHANGE. *JMIR Hum. Factors* 9:e37372. doi: 10.2196/37372
- Asensio, O. I., and Delmas, M. A. (2016). The dynamics of behavior change: Evidence from energy conservation. *J. Econ. Behav. Organ.* 126:196–212. doi: 10.1016/j.jebo.2016.03.012
- Bailey, J. O., Bailenson, J. N., Flora, J., Armel, K. C., Voelker, D., and Reeves, B. (2015). The impact of vivid messages on reducing energy consumption related to hot water use. *Environ. Behav.* 47, 570–592. doi: 10.1177/0013916514551604
- Bastida, L., Cohen, J. J., Kollmann, A., Moya, A., and Reichl, J. (2019). Exploring the role of ICT on household behavioural energy efficiency to mitigate global warming. *Renew. Sust. Energ. Rev.* 103, 455–462. doi: 10.1016/j.rser.2019.01.004
- Bates, S., Clapton, J., and Coren, E. (2007). Systematic maps to support the evidence base in social care. *Evid. Policy* 3, 539–551. doi: 10.1332/174426407782516484
- Berger, S., Kilchenmann, A., Lenz, O., and Schlöder, F. (2022). Willingness-to-pay for carbon dioxide offsets: field evidence on revealed preferences in the aviation industry. *Glob. Environ. Chang.* 73:102470. doi: 10.1016/j.gloenvcha.2022.102470
- Blascovich, J., and Bailenson, J. (2011). *Infinite reality: Avatars, eternal life, new worlds, and the dawn of the virtual revolution*. New York: William Morrow and Co.
- Bonaiuto, M., Mosca, O., Milani, A., Aricchio, A., Dessi, F., and Fornara, F. (2023). Beliefs about technological and contextual features drive biofuels' social acceptance. *Renew. Sust. Energ. Rev.* 189:113867. doi: 10.1016/j.rser.2023.113867
- Brenner, B., and Hartl, B. (2021). The perceived relationship between digitalization and ecological, economic, and social sustainability. *J. Clean. Prod.* 315:128128. doi: 10.1016/j.jclepro.2021.128128
- Camodeca, R., and Almici, A. (2021). Digital transformation and convergence toward the 2030 Agenda's sustainable development goals: evidence from Italian listed firms. *Sustainability* 13:11831. doi: 10.3390/su132111831
- Caruana, R., Carrington, M. J., and Chatzidakis, A. (2016). “Beyond the attitude-behaviour gap: novel perspectives in consumer ethics”: introduction to the thematic symposium. *J. Bus. Ethics* 136, 215–218. doi: 10.1007/s10551-014-2444-9
- Casado-Mansilla, D., Tsolakis, A. C., Borges, C. E., Kamara-Esteban, O., Krinidis, S., Avila, J. M., et al. (2020). Socio-economic effect on ICT-based persuasive interventions towards energy efficiency in tertiary buildings. *Energies* 13:1700. doi: 10.3390/en13071700
- Casals, M., Gangoilells, M., Macarulla, M., Forcada, N., Fuertes, A., and Jones, R. V. (2020). Assessing the effectiveness of gamification in reducing domestic energy consumption: lessons learned from the EnerGAWare project. *Energ. Buildings* 210:109753. doi: 10.1016/j.enbuild.2019.109753
- Castro, G. D. R., Fernandez, M. C. G., and Colsa, Á. U. (2021). Unleashing the convergence amid digitalization and sustainability towards pursuing the sustainable development goals (SDGs): a holistic review. *J. Clean. Prod.* 280:122204. doi: 10.1016/j.jclepro.2020.122204
- Chen, L., Ma, M., and Xiang, X. (2023). Decarbonizing or illusion? How carbon emissions of commercial building operations change worldwide. *Sustain. Cities Soc.* 96:104654. doi: 10.1016/j.scs.2023.104654
- Chen, B., and Sintov, N. (2016). Bridging the gap between sustainable technology adoption and protecting natural resources: predicting intentions to adopt energy management technologies in California. *Energy Res. Soc. Sci.* 22, 210–223. doi: 10.1016/j.erss.2016.10.003
- Chirico, A., Scurati, G. W., Maffi, C., Huang, S., Graziosi, S., Ferrise, F., et al. (2021). Designing virtual environments for attitudes and behavioral change in plastic consumption: a comparison between concrete and numerical information. *Virtual Reality* 25, 107–121. doi: 10.1007/s10055-020-00442-w
- Chiu, M. C., Kuo, T. C., and Liao, H. T. (2020). Design for sustainable behavior strategies: impact of persuasive technology on energy usage. *J. Clean. Prod.* 248:119214. doi: 10.1016/j.jclepro.2019.119214
- Clapton, J., Rutter, D., and Sharif, N. (2009). *SCIE systematic mapping guidance*. <https://www.scie.org.uk/publications/researchresources/rr03.pdf> (Accessed April, 2009).
- Coen, S., Drumm, I., and Fantinelli, S. (2019). Promoting pro-environmental behaviour through augmented reality and persuasive informational power: a pilot study. *Hum. Aff.* 29, 339–351. doi: 10.1515/humaff-2019-0028
- Coghlan, A. (2020). Mobilising knowledge: an action design research case study of using technology to safeguard an endangered nature-based tourism attraction. *J. Sustain. Tour.* 30, 2187–2206. doi: 10.1080/09669582.2020.1838530
- Collaboration for Environmental Evidence. (2018). *Guidelines and standards for evidence synthesis in environmental management*. Version 5.0. Available at: <https://www.environmentalevidence.org/information-for-authors>
- Comber, R., Thieme, A., Rafiev, A., Taylor, N., Krämer, N., and Olivier, P. (2013). *BinCam: designing for engagement with Facebook for behavior change*. In: IFIP conference on human-computer interaction. Berlin: Springer, pp. 99–115.
- Cropley, M., Sprajcer, M., and Dawson, D. (2022). Wastogram: validation of a new tool to measure household food waste. *Journal of environmental psychology*, 84, 101896. Darby, S. (2010). Smart metering: what potential for household engagement? *Build. Res. Inf.* 84, 101896–101457. doi: 10.1016/j.jenvp.2022.101896
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q.* 13, 319–340. doi: 10.2307/249008
- De Salas, K., Ashbarry, L., Seabourne, M., Lewis, I., Wells, L., Dermoudy, J., et al. (2022). Improving environmental outcomes with games: an exploration of Behavioural and technological design and evaluation approaches. *Simul. Gaming* 53, 470–512. doi: 10.1177/10468781221114160
- De Salas, F., Aricchio, S., Albers, T., Alves, S., Ludovico, N., and Bonaiuto, M. (2022). Sustainable technology acceptability: mapping technological, contextual, and social psychological determinants of EU stakeholders' biofuel acceptance. *Renew. Sust. Energ. Rev.* 158:112114. doi: 10.1016/j.rser.2022.112114

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1234349/full#supplementary-material>

- Di Fabio, A. (2021). The psychology of sustainability and sustainable development: transdisciplinary perspectives. *J. Psychol. Afr.* 31, 441–445. doi: 10.1080/14330237.2021.1978670
- Dicheva, D., Dichev, C., Agre, G., and Angelova, G. (2015). Gamification in education: a systematic mapping study. *J. Educ. Technol. Soc.* 18, 75–88.
- Eggert, S., Nitsch, A., Boone, W. J., Nückles, M., and Bögeholz, S. (2017). Supporting students' learning and socioscientific reasoning about climate change—the effect of computer-based concept mapping scaffolds. *Res. Sci. Educ.* 47, 137–159. doi: 10.1007/s11165-015-9493-7
- Ettema, D., Friman, M., Gärling, T., and Olsson, L. E. (2016). “Travel Mode Use, Travel Mode Shift and Subjective Well-Being: overview of Theories”, *Empirical Findings and Policy Implications, in Mobility, Sociability and Well-being of Urban Living*. Eds. D. Wang and S. He. (Springer, Berlin, Heidelberg).
- Feng, Y. (2018). Facilitator or inhibitor? The use of 360-degree videos for immersive brand storytelling. *J. Interact. Advert.* 18, 28–42. doi: 10.1080/15252019.2018.1446199
- Feroz, A. K., Zo, H., and Chiravuri, A. (2021). Digital transformation and environmental sustainability: a review and research agenda. *Sustainability* 13:1530. doi: 10.3390/su13031530
- Filippou, J., Cheong, C., and Cheong, F. (2015). *Combining the Fogg behavioural model and hook model to design features in a persuasive app to improve study habits*. In: Proceedings of the 26th Australasian conference on information systems (ACIS 2015). AIS Electronic Library (AISeL), pp. 1–15.
- Fox, J., McKnight, J., Sun, Y., Maung, D., and Crawfis, R. (2020). Using a serious game to communicate risk and minimize psychological distance regarding environmental pollution. *Telematics Inform.* 46:101320. doi: 10.1016/j.tele.2019.101320
- Grassini, S., Laumann, K., and Rasmussen Skogstad, M. (2020). The use of virtual reality alone does not promote training performance (but sense of presence does). *Front. Psychol.* 11:1743. doi: 10.3389/fpsyg.2020.01743
- Haddaway, N. R., Bernes, C., Jonsson, B. G., and Hedlund, K. (2016). The benefits of systematic mapping to evidence-based environmental management. *Ambio* 45, 613–620. doi: 10.1007/s13280-016-0773-x
- Haddaway, N. R., Macura, B., Whaley, P., and Pullin, A. S. (2018). ROSES RepOrting standards for systematic evidence syntheses: pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps. *Environ. Evid.* 7, 1–8. doi: 10.1186/s13750-018-0121-7
- Hafner, R., Elmes, D., Read, D., and White, M. P. (2019). Exploring the role of normative, financial and environmental information in promoting uptake of energy efficient technologies. *J. Environ. Psychol.* 63, 26–35. doi: 10.1016/j.jenvp.2019.03.004
- Ham, J., and Midden, C. J. (2014). A persuasive robot to stimulate energy conservation: the influence of positive and negative social feedback and task similarity on energy-consumption behavior. *Int. J. Soc. Robot.* 6, 163–171. doi: 10.1007/s12369-013-0205-z
- Harmon, D., and Gauvain, M. (2019). Influence of internet-based messages and personal motivations on water-use decisions. *Basic Appl. Soc. Psychol.* 41, 341–358. doi: 10.1080/01973533.2019.1654866
- Hedin, B., Katzeff, C., Eriksson, E., and Pargman, D. (2019). A systematic review of digital behaviour change interventions for more sustainable food consumption. *Sustainability* 11:2638. doi: 10.3390/su11092638
- Henn, L., Taube, O., and Kaiser, F. G. (2019). The role of environmental attitude in the efficacy of smart-meter-based feedback interventions. *J. Environ. Psychol.* 63, 74–81. doi: 10.1016/j.jenvp.2019.04.007
- Hilty, L. M., and Aebischer, B. (2015). “ICT for sustainability: an emerging research field” in *ICT innovations for sustainability. Advances in intelligent systems and computing*. eds. L. Hilty and B. Aebischer, vol. 310 (Cham: Springer)
- Horton, J., Haagevik, R., Adkinson, B., and Parmly, J. (2013). Get connected: incorporating technology into your lessons does not mean you have to stay indoors! *Sci. Child.* 50, 44–49.
- Isensee, C., Teuteberg, F., Griesse, K. M., and Topi, C. (2020). The relationship between organizational culture, sustainability, and digitalization in SMEs: a systematic review. *J. Clean. Prod.* 275:122944. doi: 10.1016/j.jclepro.2020.122944
- James, K. L., Randall, N. P., and Haddaway, N. R. (2016). A methodology for systematic mapping in environmental sciences. *Environ. Evid.* 5, 1–13. doi: 10.1186/s13750-016-0059-6
- Janpol, H. L., and Dilts, R. (2016). Does viewing documentary films affect environmental perceptions and behaviors? *Appl Environ Educ Commun*, 15, 90–98. doi: 10.1080/1533015X.2016.1142197
- Khashe, S., Lucas, G., Becerik-Gerber, B., and Gratch, J. (2019). Establishing social dialog between buildings and their users. *Int. J. Hum.-Comput. Interact.* 35, 1545–1556. doi: 10.1080/10447318.2018.1555346
- Kimura, H., and Nakajima, T. (2011). Designing persuasive applications to motivate sustainable behavior in collectivist cultures. *Psychol. J.* 9:53.
- Kok, G., Peters, L. W. H., and Ruiter, R. A. C. (2017). Planning theory- and evidence-based behavior change interventions: a conceptual review of the intervention mapping protocol. *Psicol. Refl. Crit.* 30:19. doi: 10.1186/s41155-017-0072-x
- Lange, F., Berger, S., Byrka, K., Brügger, A., Henn, L., Sparks, A. C., et al. (2023). Beyond self-reports: a call for more behavior in environmental psychology. *J. Environ. Psychol.* 86:101965. doi: 10.1016/j.jenvp.2023.101965
- Lopreiato, J. O. (2016). *Healthcare simulation dictionary*. Rockville, MD: Agency for Healthcare Research and Quality.
- Mahmud, S. N. D., Husnin, H., and Tuan Soh, T. M. (2020). Teaching presence in online gamified education for sustainability learning. *Sustainability* 12:3801. doi: 10.3390/su12093801
- Mahood, Q., Van Eerd, D., and Irvin, E. (2014). Searching for grey literature for systematic reviews: challenges and benefits. *Res. Synth. Methods* 5, 221–234. doi: 10.1002/jrsm.1106
- Martínez-Borreguero, G., Perera-Villalba, J. J., Mateos-Núñez, M., and Naranjo-Correa, F. L. (2020). Development of ICT-based didactic interventions for learning sustainability content: cognitive and affective analysis. *Sustainability* 12:3644. doi: 10.3390/su12093644
- Mensah, J. (2019). Sustainable development: meaning, history, principles, pillars, and implications for human action: literature review. *Cogent Soc. Sci.* 5:1653531. doi: 10.1080/23311886.2019.1653531
- Moore, M. M., and Yang, J. Z. (2020). Using eco-guilt to motivate environmental behavior change. *Environ. Commun.* 14, 522–536. doi: 10.1080/17524032.2019.1692889
- Mozo-Reyes, E., Jambeck, J. R., Reeves, P., and Johnsen, K. (2016). Will they recycle? Design and implementation of eco-feedback technology to promote on-the-go recycling in a university environment. *Resour. Conserv. Recycl.* 114, 72–79. doi: 10.1016/j.resconrec.2016.06.024
- Murthy, D. (2013). Ethnographic research 2.0: the potentialities of emergent digital technologies for qualitative organizational research. *J. Organ. Ethnogr.* 2, 23–36. doi: 10.1108/JOE-01-2012-0008
- Nelson, K. M., Anggraini, E., and Schlüter, A. (2020). Virtual reality as a tool for environmental conservation and fundraising. *PLoS One* 15:e0223631. doi: 10.1371/journal.pone.0223631
- Oh, J., Sudarshan, S., Jin, E., Nah, S., and Yu, N. (2020). How 360-degree video influences content perceptions and environmental behavior: the moderating effect of environmental self-efficacy. *Sci. Commun.* 42, 423–453. doi: 10.1177/1075547020932174
- Oliveira, L., Mitchell, V., and May, A. (2016). Reducing temporal tensions as a strategy to promote sustainable behaviours. *Comput. Hum. Behav.* 62, 303–315. doi: 10.1016/j.chb.2016.04.004
- Oppong-Tawiah, D., Webster, J., Staples, S., Cameron, A. F., de Guinea, A. O., and Hung, T. Y. (2020). Developing a gamified mobile application to encourage sustainable energy use in the office. *J. Bus. Res.* 106, 388–405. doi: 10.1016/j.jbusres.2018.10.051
- Ouariachi, T., Olvera-Lobo, M. D., and Gutiérrez-Pérez, J. (2019). Serious games and sustainability. *Encycl. Sustain. High. Educ.* 2019, 1450–1458. doi: 10.1007/978-3-030-11352-0_326
- Piras, F., Manca, S., Sottile, E., Meloni, I., Mosca, O., Tuveri, G., et al. (2021). Can persuasive normative messages encourage sustainable transportation usage? *Transp. Res. Part F Psychol. Behav.* 83:304–322. doi: 10.1016/j.trf.2021.10.014
- Pereira-Doel, P., Font, X., Wyles, K., and Pereira-Moliner, J. (2019). Showering smartly. A field experiment using water-saving technology to foster pro-environmental behaviour among hotel guests. *E Rev. Tour. Res.* 17:525.
- Randall, N. P., and James, K. L. (2012). The effectiveness of integrated farm management, organic farming and Agri-environment schemes for conserving biodiversity in temperate Europe—a systematic map. *Environ. Evid.* 1, 4–21. doi: 10.1186/2047-2382-1-4
- Reihana, K., Taura, Y., and Harcourt, N. (2019). He tohu o te wā—Hangarau pūtaiao/ signs of our times—fusing technology with environmental sciences. *N. Z. J. Ecol.* 43, 1–9. doi: 10.20417/nzjcol.43.31
- Rogers, E. M. (2010). *Diffusion of innovations*. New York: Simon and Schuster.
- Rosen, M. A. (2017). Sustainable development: A vital quest. *Eur. J. Sustain. Dev. Res.* 1:2. doi: 10.20897/ejosdr.201702
- Ruscio, D., Caruso, G., Mussone, L., and Bordegoni, M. (2018). Eco-driving for the first time: the implications of advanced assisting technologies in supporting pro-environmental changes. *Int. J. Ind. Ergon.* 64, 134–142. doi: 10.1016/j.ergon.2018.01.009
- Schaal, S., Otto, S., Schaal, S., and Lude, A. (2018). Game-related enjoyment or personal pre-requisites—which is the crucial factor when using geogames to encourage adolescents to value local biodiversity. *Int. J. Sci. Educ. Part B* 8, 213–226. doi: 10.1080/21548455.2018.1441571
- Schild, D. (2020). 22 ways to leave home without actually leaving the couch, from virtual zoo exhibits to museum gallery tours. <https://www.insider.com/museumstheme-parks-offer-virtual-tours-ideal-for-social-distancing-2020-3>.
- Schultz, P. W., and Oskamp, S. (1996). Effort as a moderator of the attitude-behavior relationship: General environmental concern and recycling. *Soc. Psychol. Q.* 375–383. doi: 10.2307/2787078
- Schwartz, T., Stevens, G., Jakobi, T., Denef, S., Ramirez, L., Wulf, V., et al. (2015). What people do with consumption feedback: a long-term living lab study of a home energy management system. *Interact. Comput.* 27, 551–576. doi: 10.1093/iwc/iwu009
- Seaborn, K., and Fels, D. I. (2015). Gamification in theory and action: a survey. *Int. J. Hum. Comput. Stud.* 74, 14–31. doi: 10.1016/j.jihcs.2014.09.006
- Sivak, M., and Schoettle, B. (2012). Eco-driving: strategic, tactical, and operational decisions of the driver that influence vehicle fuel economy. *Transp. Policy* 22, 96–99. doi: 10.1016/j.tranpol.2012.05.010

- Skamp, K., Boyes, E., and Stanisstreet, M. (2013). Beliefs and willingness to act about global warming: Where to focus science pedagogy?. *Sci Educ*, 97, 191–217. doi: 10.1002/sce.21050
- Soliman, M., Peetz, J., and Davydenko, M. (2017). The impact of immersive technology on nature relatedness and pro-environmental behavior. *J. Med. Psychol.* 29, 8–17. doi: 10.1027/1864-1105/a000213
- Spence, A., Leygue, C., Bedwell, B., and O'Malley, C. (2014). Engaging with energy reduction: does a climate change frame have the potential for achieving broader sustainable behaviour? *J. Environ. Psychol.* 38, 17–28. doi: 10.1016/j.jenvp.2013.12.006
- Stern, P. C. (2000). Toward a coherent theory of environmentally significant behavior. *J. Soc. Issues* 56, 407–424. doi: 10.1111/0022-4537.00175
- Strange Loop Games (2015). *Eco, Version Beta; Strange Loop Games: Seattle, WA, USA.*
- Tiefenbeck, V., Wörner, A., Schöb, S., Fleisch, E., and Staake, T. (2019). Real-time feedback promotes energy conservation in the absence of volunteer selection bias and monetary incentives. *Nat. Energy* 4, 35–41. doi: 10.1038/s41560-018-0282-1
- Tiefenbeck, V., Goette, L., Degen, K., Tasic, V., Fleisch, E., Lalive, R., et al (2018). Overcoming salience bias: How real-time feedback fosters resource conservation. *Manage Sci.*, 64, 1458–1476. doi: 10.1287/mnsc.2016.2646
- United Nations. (2015). *The 2030 agenda for sustainable development*. Paris, France: United Nations.
- von Borgstede, C., and Biel, A. (2002). Pro-environmental behaviour: Situational barriers and concern for the good at stake. *Göteborg Psychological Reports*, 32, N.1.
- WCED. (1987). *World commission on environment and development: Our common future*. Oxford: Oxford University Press.
- Wemyss, D., Cellina, F., Lobsiger-Kägi, E., De Luca, V., and Castri, R. (2019). Does it last? Long-term impacts of an app-based behavior change intervention on household electricity savings in Switzerland. *Energy Res. Soc. Sci.* 47, 16–27. doi: 10.1016/j.erss.2018.08.018
- Wheaton, M., Ardoin, N. M., Hunt, C., Schuh, J. S., Kresse, M., Menke, C., et al. (2016). Using web and mobile technology to motivate pro-environmental action after a nature-based tourism experience. *J. Sustain. Tour.* 24, 594–615. doi: 10.1080/09669582.2015.1081600
- Won, J. (2018). PSPB (persuasive service design strategies based on the theory of planned behavior) methodology for user behavior modification. *Arch. Des. Res.* 31, 17–30. doi: 10.15187/adr.2018.08.31.3.17
- Xiang, X., Zhou, N., Ma, M., Feng, W., and Yan, R. (2023). Global transition of operational carbon in residential buildings since the millennium. *Adv. Appl. Energy* 11:100145. doi: 10.1016/j.adapen.2023.100145
- Zou, C., Ma, M., Zhou, N., Feng, W., You, K., and Zhang, S. (2023). Toward carbon free by 2060: a decarbonization roadmap of operational residential buildings in China. *Energy* 277:127689. doi: 10.1016/j.energy.2023.127689



OPEN ACCESS

EDITED BY

Christian Andreas Klöckner,
NTNU, Norway

REVIEWED BY

Glenda Garza,
University of Sonora, Mexico
Giuseppe Carrus,
Roma Tre University, Italy

*CORRESPONDENCE

Kane Baker

✉ kb948@bath.ac.uk;

✉ kane.baker@bath.edu

Elizabeth Marks

✉ e.marks@bath.ac.uk

RECEIVED 04 September 2023

ACCEPTED 21 March 2024

PUBLISHED 24 April 2024

CITATION

Baker K, Chioran B and Marks E (2024)
“Eco-caring together” pro-ecological group-
based community interventions and mental
wellbeing: a systematic scoping review.
Front. Psychol. 15:1288791.
doi: 10.3389/fpsyg.2024.1288791

COPYRIGHT

© 2024 Baker, Chioran and Marks. This is an
open-access article distributed under the
terms of the [Creative Commons Attribution
License \(CC BY\)](#). The use, distribution or
reproduction in other forums is permitted,
provided the original author(s) and the
copyright owner(s) are credited and that the
original publication in this journal is cited, in
accordance with accepted academic
practice. No use, distribution or reproduction
is permitted which does not comply with
these terms.

“Eco-caring together” pro-ecological group-based community interventions and mental wellbeing: a systematic scoping review

Kane Baker*, Bianca Chioran and Elizabeth Marks*

Department of Psychology, University of Bath, Bath, United Kingdom

Background: Poor mental wellbeing is a challenge for societies across the world, as is the increasing threat of climate change, and emerging evidence suggests these challenges are interrelated. Green and social prescribing of non-clinical interventions hold promise as a cost-effective and widely accessible way to improve wellbeing, and interest is growing in whether pro-ecological communal activities have mutual benefits for both people and the planet.

Objectives: Communal pro-ecological activities are growing in popularity, and research is gathering pace into whether participation influences mental wellbeing. The present systematic review scopes the existing evidence base to explore what is being done, what is being found, and what additional research is required.

Methods: Electronic databases (PsychNET, PubMed, Scopus, and Web of Science) were searched for studies that involved groups of people undertaking pro-ecological activities, where components of mental wellbeing were assessed. Eligibility criteria were purposely broad, including all study designs and participants across the lifespan.

Results: Thirty-seven eligible studies were identified. Nearly half of the studies used mixed-method designs, and most studies used surveys or interviews to evaluate outcomes. Most pro-ecological activities involved planting vegetation, and habitat creation, maintenance, or restoration. Methodological quality varied considerably. Among the perceived therapeutic mechanisms reported, the social elements of the interventions were prominent.

Discussion: Coherent synthesis of the current evidence base is challenging given the heterogeneous range of methods, samples, and interventions within the studies. However, the results here demonstrate promise that with future research and better methodological rigor, pro-ecological group-based interventions hold the potential to improve mental wellbeing and influence sustainable behavior.

Systematic review registration: <https://osf.io/vmpr6/>.

KEYWORDS

nature-based interventions, pro-environmental behavior (PEB), conservation, social integration, mental health, pro-social behavior, climate anxiety

1 Introduction

Poor mental health and the climate and ecological crises are two of the most significant issues facing humankind globally (Lawrance et al., 2021). The disabling consequences of mental distress impact around one billion people worldwide (Institute for Health Metrics and Evaluation, 2017), and in the U.K., one in four adults in any given year experiences at least one diagnosable mental health condition (NHS England, 2021). Alongside this, the insidious adverse consequences of the changing climate and related ecological degradation and biodiversity loss, are progressively disastrous for humans (e.g., Kjellstrom et al., 2018). We are seeing increasing numbers of extreme weather events, meaning growing numbers of people are being directly impacted by climate change in a way that causes distress (Intergovernmental Panel on Climate Change, 2021; Lawrance et al., 2021).

In addition, there is evidence that even the awareness of the climate and ecological crises causes mental distress for many people (Pihkala, 2020). Various described eco-anxiety, ecological grief, and solastalgia, involving the experience of painful emotional and cognitive responses to the climate crisis including anxiety, sadness, and anger, are growing in recognition (Clayton and Karazsia, 2020; Stanley et al., 2021). Rates of such eco-distress are increasingly significant, particularly in younger populations (Hickman, 2020). Although not a mental illness (e.g., Lawton, 2019), distress related to the climate and ecological crises is a chronic and inescapable stressor that may increase vulnerability to other mental health problems (e.g., Zuckerman, 1999).

As such, there is growing evidence that the climate and ecological crises have a significant, complex, and evolving impact on human mental health and wellbeing (Lawrance et al., 2021). This relationship is complicated by findings that, in contrast, pro-environmental behavior and connection to nature are associated with subjective wellbeing (Chukwuorji et al., 2017). This indicates how such issues are intertwined, and with the deterioration of the natural world, the mental health difficulties of global populations will inevitably grow more problematic (Romeu, 2021). For example, a correlating factor is the rising rate of modern urbanized living, which can have negative impacts on mental health through the increased isolation, loneliness, and disconnection such lifestyles can create (Zijlema et al., 2015; Klusman et al., 2020). Alongside this, the loss of natural environments may limit how much access many people have to nature and its positive wellbeing impacts.

The gap that exists between mental distress and effective treatment (Wainberg et al., 2017) woefully resembles the gap seen between climate change and mitigative action (Intergovernmental Panel on Climate Change, 2021). In England and Wales, only one in eight people receive treatment for their mental health problem, most commonly, medication (McManus et al., 2009, 2016; Welsh Government, 2016). For children, where mental health difficulties can have dramatic long-term consequences, only a quarter with a diagnosed psychiatric disorder had contact with a mental health specialist in 2017, and over 20% of these children waited longer than 6 months (Sadler et al., 2018). It is thus essential to develop novel, scalable, efficient, and timely interventions, while improving social support networks to tackle this increasing mental health burden, particularly considering the context of limited funding for services.

Green-prescribing is an umbrella term for nature-based non-clinical interventions that are offered to people to alleviate distress and improve their mental wellbeing (Leavell et al., 2019). Several theories explain why nature contact is beneficial. The Biophilia Hypothesis (Wilson, 1984) suggests that the human brain evolved in a biocentric world, attuning it to extract, process, and evaluate information in the natural environment. As such, humans have a genetically predisposed attraction to nature, for which we seek connection with (Wilson, 1993). Moreover, Habitat Selection Theory (Orians and Heerwagen, 1992) poses those natural surroundings aided survival through evolution, and as such, attraction to them is cross-cultural and universal. Such theories, however, may oversimplify the complexity of nature-wellbeing links in a rapidly modernizing and changing world (e.g., Joye and De Block, 2011). Nonetheless, simply spending time in nature can be beneficial for mental wellbeing, and it has been suggested that this is through cognitive restoration and reducing stress (Bragg and Atkins, 2016; Richardson et al., 2021). Indeed, Attention Restoration Theory (Kaplan and Kaplan, 1989) suggests that exposure to nature can replenish concentration and reduce mental fatigue, and Stress Reduction Theory (Ulrich et al., 1991) poses that looking at natural scenery can improve emotional and physiological states, aiding emotional regulation through an involuntary reduction of arousal.

Social prescribing is another umbrella term for non-clinical interventions that promote group community-based activities, which are also considered beneficial for mental health (e.g., Esmene et al., 2020). The Main Effect Model (Rook, 1990) suggests that social integration provides regular positive and rewarding experiences that bolster feelings of security, purpose, and belonging, whereas the Stress-Buffering Model (Cohen and Wills, 1985) suggests that social relations can promote our perceived ability to cope with imposed life stresses. Though such theories can overgeneralise the complexity of social interaction and relationships across individuals and cultures (e.g., Landerman et al., 1989), studies from the realm of community psychology generally show that a sense of responsibility, belonging, and cohesion within a neighborhood is linked to mental wellbeing (Sarason, 1974; Elliott et al., 2014). Given that social disconnection and loneliness predict mental distress (Klusman et al., 2020), social prescribing makes sense, and networking among people with shared experiences, concerns, or disorders can be therapeutic (e.g., Isaksson et al., 2021).

A shared intent, or perhaps a by-product of green and social prescribing, is encouraging physical activity to promote mental wellbeing (Chatterjee et al., 2018). Various biological and psychological theories describe this link. For instance, the Endorphin Hypothesis (Hoffman, 1997) states that exercise increases the release of β -endorphins that stimulates positive mood, whereas the Self-Efficacy Hypothesis (Craft, 2005) suggests that exercise provides a meaningful mastery experience that can boost self-belief and confidence.

With theory and evidence highlighting the health benefits of being in nature and joining community activities, there is a strong argument for combining green and social activity prescribing. Participating in nature-based group activities could offer particularly powerful benefits (Fixsen and Barrett, 2022), and evidence supports this claim. For instance, group nature walks are shown to have greater health benefits than group walks in urban areas or walking alone (e.g., Marselle et al., 2013; Hanson and Jones, 2015).

However, green social prescribing interventions have the potential to go even further; by moving from “*being in*” to “*doing with*” nature. Pro-ecological group-based activities such as communal tree planting have great potential for positive mental health impacts as they incorporate multiple elements, each offering particular benefits. This includes exposure to nature, social connection, and exercise as discussed, but also implicates pro-social and pro-environmental behavior (e.g., O’Brien et al., 2010; Taufik et al., 2015; Martin et al., 2020). Such behaviors, involving actions intended to benefit others or the environment (e.g., Penner et al., 2005; Steg and Vlek, 2009), are beneficial for mental wellbeing cross-culturally (Hui et al., 2020; Capstick et al., 2022), and a new reciprocal model proposes that a positive feedback loop exists between prosocial behavior and mental health (Hui, 2022). Response Shift Theory (Schwartz and Sendor, 1999) poses that pro-social behavior can shift internal values to help people realize the meaning and value of life and distract them from their own worries and stress. Similarly, the Negative-state Relief Model (Cialdini and Kenrick, 1976) suggests that pro-social action helps to reduce negative mood, whereas the Warm-Glow Theory focuses on the experienced joy and satisfaction people gain from doing good for others or the environment (Andreoni, 1989; Hartmann et al., 2017).

As people become increasingly concerned and interested in current threats to the natural world, pro-environmental behavior may be of particular importance. Empowerment Theory (Perkins and Zimmerman, 1995) is thus relevant here, suggesting that people can gain self-esteem, self-efficacy, and internalized locus of control through collective action and group participation involving mutual respect, caring, and reflection to achieve goals. Evidence already indicates that pro-ecological collective action can promote wellbeing components, such as active hope, in those experiencing eco-related distress (e.g., Nairn, 2019; Stanley et al., 2021).

With multiple hypothesized processes at play, it is unlikely that any single theory can capture what might be happening in these activities. Nonetheless, “*eco-caring together*” interventions are receiving greater attention as they offer benefits for human mental health and planetary health (Robinson and Breed, 2019; Breed et al., 2020). Given the influences of collective issues such as loneliness and eco-distress on mental suffering, focusing treatments and responses upon the individual could be seen as contradictory, while more community-focused remedies seem increasingly appropriate. Despite such promise, the shape and extent of the literature investigating pro-ecological group-based interventions are unclear, possibly due to the heterogeneity of such interventions and assessment methods. This systematic review aims to scope the state of the literature on studies that have explored pro-ecological, group-based community activities and their influence on mental wellbeing.

To our knowledge, the only review of environmental enhancement interventions and their links to human health conducted was by Husk et al. (2016). Their searches in 2012 found 19 eligible studies, which were widely heterogeneous in terms of samples, designs, and evaluation methods. There was a strong risk of bias as the majority of studies were program evaluations funded by intervention providers. The authors concluded that little quantitative evidence exists showing the benefits, but qualitative data showed some perceived benefits. The review was very broad, attempting to synthesize evidence from both group and $n=1$ studies for both mental and physical health. Additionally, some activities included elements that were arguably not pro-environmental, but rather, aesthetic work in nature (e.g., pathway

creation), and the review excluded activities such as communal gardening. Nonetheless, a main conclusion was the inherent difficulty with generating robust evidence for such interventions, and recommendations for linked reviews to refine the understanding of environmental interventions were made.

This review comes a decade on from Husk et al. (2016) searches, at a time when understanding and concern around environmental issues are much greater, among both the public and researchers. The current review employed a refined scope, searching for literature relating to group-based interventions, with pro-ecological elements, that focussed on mental wellbeing. Six research questions guided this review to explore what the evidence base now looks like, shedding light on whether it is time to conduct a more definitive systemic review or meta-analysis:

- 1 What is the current state of the evidence base for pro-ecological, group-based activities to promote mental wellbeing? (*Primary Question*)
- 2 What study designs are used to evaluate such interventions?
- 3 How are such interventions evaluated, and what key outcome measures are utilized?
- 4 Are there indications of the perceived therapeutic mechanisms of such interventions?
- 5 Are there indications of the acceptability and challenges of such interventions?
- 6 Are there any indications about how such approaches are experienced by people reporting eco-related distress?

2 Materials and methods

2.1 Protocol and registration

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidance 2020 (Page et al., 2021) and extension for scoping reviews (PRISMA-ScR) (Tricco et al., 2018) were followed. The protocol was registered on the Open Science Framework¹ before searching began.

2.2 Eligibility criteria

The criteria were set broadly without date restrictions with an aim to capture the anticipated heterogeneity of relevant literature. Studies were included if they reported adult or child participants (with or without reported mental distress) involved in a group activity or intervention that contained pro-ecological elements, and where outcomes included at least one measure or report of mood, affect, life satisfaction, mental health, or wellbeing. Studies were excluded if they focussed solely on physical health, or if pro-ecological experiences were via paid employment. All study designs were included. Articles that were not in or translatable to English were excluded.

¹ <https://osf.io/vmpr6>

2.3 Search strategy and information sources

The search strategy was built to find studies that met four broad search targets: (1) pro-ecological activities/natural environments, (2) involving group/community participation, (3) reporting interventions/volunteering trials, which (4) included wellbeing/mood measurement (see [Supplementary Appendix A](#)). Search terms were generated using relevant literature to explore existing descriptors of pro-ecological actions and settings. In this review, “pro-ecological” refers to interventions that actively involve elements of green, sustainable, or eco-friendly behavior that have protective or enriching actions toward biodiversity or the environment. Synonyms for “group” and “intervention” were applied, and descriptors relating broadly to mental wellbeing were sourced through MeSH terms.

A systematic search of PsychNET, PubMed, Scopus and Web of Science databases was conducted on 26th January 2022. The search terms were applied to the title, abstract and keywords (for all database-specific search terms and limit filters, see [Supplementary Appendix A](#)). Reference lists from eligible studies were skimmed to identify further eligible studies. Generic online searches were completed on popular search engines to scope relevant gray literature and third-party organization reports. Finally, the WHO’s International Clinical Trials Registry Platform (ICTRP; trialsearch.who.int) and ClinicalTrials.gov (clinicaltrials.gov) were consulted for completed unpublished trials, using the search term “nature-based” OR “pro-ecological” AND “wellbeing” to maximize sensitivity ([Hunter et al., 2022](#)).

2.4 Source selection and management

Following database searches, records were managed using [Covidence \(2022\)](#) software. Duplicate records were immediately removed. At screening stage one, the primary reviewer (KB) independently screened all titles and abstracts for further full-text review eligibility. At stage two, full-text records were independently double-screened by the primary and secondary reviewers (KB, BC) for inclusion. Discrepancies were resolved by discussion between the two reviewers, and the senior author (EM) was consulted where consensus was not reached.

2.5 Data items and charting

The data-charting form developed by the lead author (KB) was trialed by both reviewers (KB, BC) and refined. Data of interest were guided by the research questions; primarily, intervention types, summary findings, study designs, evaluation methods, acceptability findings, and reported therapeutic mechanisms. Additional data extracted included: sample recruitment, size, and characteristics, publication type, and country of origin. Data from the included studies was charted by either reviewer (KB, BC) using [Covidence \(2022\)](#) software and then cross-checked by the other to ensure consistency and accuracy.

2.6 Critical appraisal

The Mixed Methods Assessment Tool (MMAT) ([Pluye et al., 2009](#); see [Supplementary Appendix C](#)) was used to evaluate the quality of included studies, enabling assessment of both the state and strength of the evidence base. The MMAT is a single integrated tool that allows the assessment of quantitative, qualitative, and mixed-methods studies. Two screening questions were initially applied to each study; (i) is there a clear research question? (ii) does the data collected address this question? Studies failing these questions, or not reporting any outcomes, were not suitable for the MMAT. Studies meeting criteria were further assessed using five (“yes”/“no”) criteria relevant to the methodology used. The number of criteria met (scored “yes”) was calculated and reported as a quality score percentage (0, 20, 40, 60, 80, 100%), allowing comparison across methodologies.

2.7 Synthesis

Extracted data was exported to Microsoft Excel for analysis. An overarching narrative synthesis was most appropriate given the heterogeneity of included studies. The synthesis and reporting were structurally guided by the research questions. Where appropriate, descriptive quantitative analysis was applied to charted data, giving frequency and percentage results.

3 Results

3.1 Sources of evidence

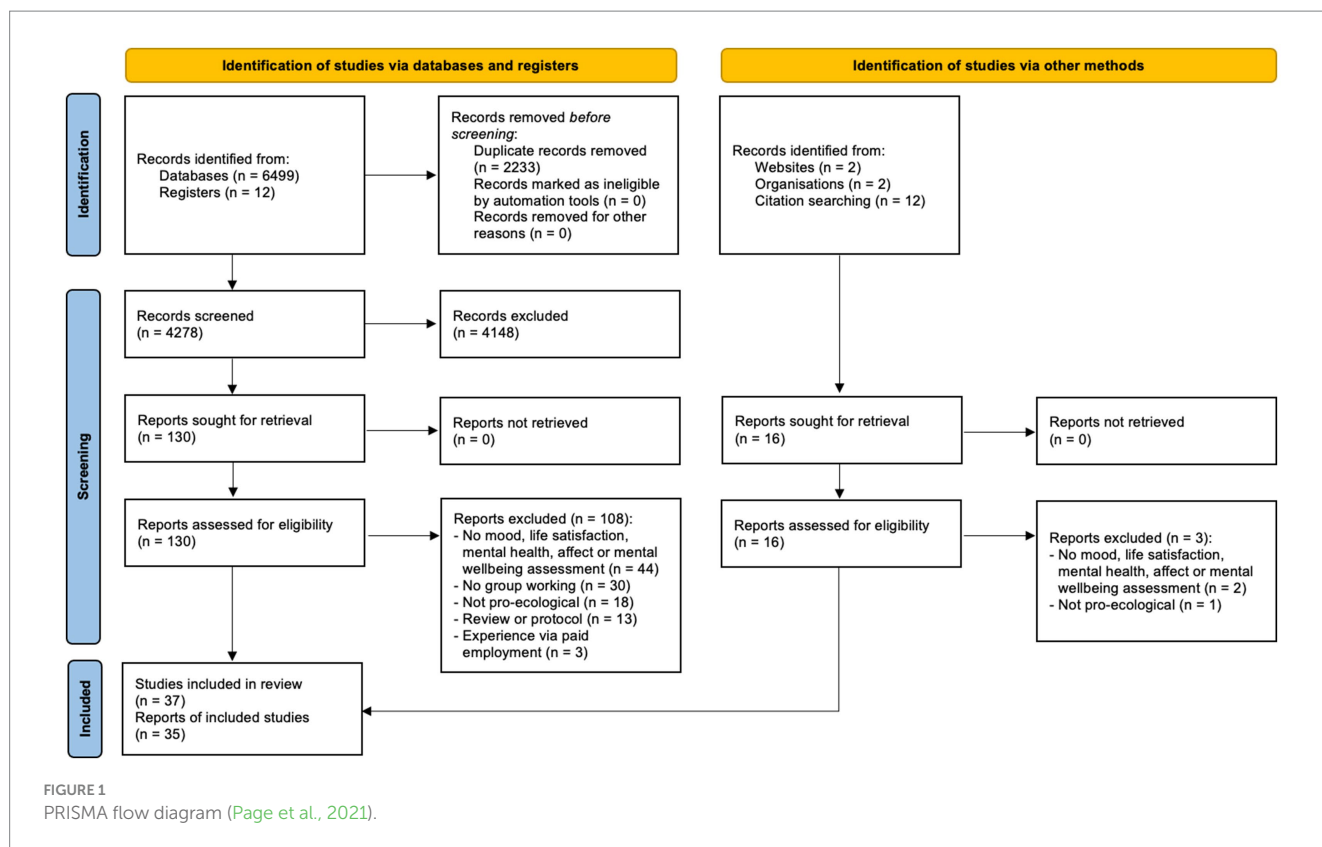
The process of study selection is shown in [Figure 1](#). The search identified 6,499 records from electronic databases, 12 records from registers, and a further 16 papers and reports were identified from other sources. After duplication removal, 4,278 papers were title and abstract screened, and 146 papers were included in the full-text screen (see [Supplementary Appendix B](#) for excluded papers and reasons). A total of 37 studies from 35 papers were eligible for inclusion ([Townsend, 2006](#); contained three distinct eligible studies).

3.2 Review question 1: Current state of evidence base (including characteristics of sources)

Data from 37 studies were charted from 35 individual papers, and key characteristics are shown in [Table 1](#). As anticipated, the range of studies was varied and diverse, reflecting the broad scope and inclusion criteria of this review. The earliest study found was from 1998, with gradually growing interest in pro-ecological activities and mental wellbeing published since.

In terms of location, studies were found across five continents, though most (46%) took place in Europe, many of which (30%) were in the UK ([Figure 2](#)). Very few studies reported participant ethnicity details.

As anticipated, the pro-ecological activities varied extensively across the studies. The range of different activities was broad, but all



had pro-ecological behavioral elements. Common themes were found across the activities (see Figure 3), and some interventions included multiple activities that fell into several categories. The most common activities involved planting new trees or growing plants (43%), or habitat creation, enhancement, or restoration (41%). Environmental management or decontamination was reported in nearly a third of studies (32%), followed by wildlife promotion (24%). Watershed management or restoration (11%), and recycling or waste management (8%) activities were also reported.

Collectively, the studies sampled 9,483 participants, of which 2,733 were control or comparison participants. Sample sizes varied considerably, with some studies opting for in-depth evaluation of small groups (e.g., $n = 3$; Birch, 2005), to larger online evaluations of national campaigns (e.g., $n = 2,453$; Bond et al., 2019). Most studies (76%) reported the age range or average age of participants and included people across the lifespan, from as young as 2 years (e.g., Sobko et al., 2020) to 81 years old (e.g., Asah and Blahna, 2013). Most studies (68%) used purposeful sampling methods, with the rest using opportunity or voluntary recruitment methods.

Most studies (62%) assessed participants who were already undertaking the activities as part of a therapeutic or volunteering group program, a campaign, or as a hobby, with implications for sampling bias, although 38% engaged new participants in pro-ecological activities. Reporting of duration and timeframes spent on the activities varied widely (Table 1), with precise activity duration reported by better-controlled studies (e.g., “20–30 min”; Coventry et al., 2019), and other studies offering more vague estimates (e.g., “most weekends”; Townsend, 2006). For studies where participants were already undertaking the activities, few reported specific

timeframes or duration of engagement (e.g., “an average of 7 years”; Moore et al., 2006).

3.3 Review question 2: Study designs (including critical appraisal of sources)

As shown in Table 2, study designs and methodologies were varied; mixed methods were most common (49%), followed by qualitative methods (27%), and then quantitative methods (24%). Most mixed methods studies (67%; $n = 12$) used surveys (four solely surveys, two with interviews, one with focus groups, and five with interviews and psychometric tools). The other six mixed-methods studies used interviews or focus groups alongside psychometric tools. All 10 qualitative studies used interviews, with three using qualitative surveys alongside, one using a focus group alongside, and one using observations alongside. Of the nine quantitative studies, six used descriptive methods, two used non-randomized group comparisons, and there was just one randomized controlled trial. Five quantitative studies used surveys plus psychometric tools, two used surveys only, and one used psychometric tools only.

Only seven studies (19%) used control groups for between-group comparison, with two using matched controls. Only one purposely allocated matched participants to control or intervention conditions, where the intervention was not previously being undertaken by participants (Tharrey et al., 2020).

The MMAT quality assessment scores (Table 2) show higher scores for studies using quantitative (mean 87%) or qualitative (mean 80%) methods, compared to mixed methods (mean 72%). Overall, quality was highly variable with no clear association with the methods utilized.

TABLE 1 Characteristics of sources.

Study (author, date; country)	Design (method; instruments)	Sample (n; characteristics; recruitment)	Pro-ecological intervention (program; activities [joint therapy]; duration)	Evaluation (time-points; measures)	Perceived therapeutic mechanisms	Key findings
Asah and Blahna (2013); USA	Mixed methods; interviews and online surveys	242; conservation group volunteers, aged 18–81, 80% white, 66% female; opportunity sampling	Volunteer-dependent urban conservation events; specific activities and duration not reported	Post-; online surveys developed from initial interviews	Making a difference; enjoyment; connecting with community; sense of belonging; social interaction	Motivations to volunteer include more satisfaction and sense of social belonging by allowing individuals to give back to the community and connect with other like-minded people
Avon Wildlife Trust (2021); UK	Mixed methods; interviews and psychometric tools	74 ($n = 22$ follow-up); conservation group volunteers, adults; purposive sampling	Green care; food growing, seed sowing, pond dipping, and creation of new meadow, insect hotel, pollinator beds, bird feeders; up to 18 weekly sessions; 4.5 h each	Pre-, Post-, 2y Follow-up; interviews, Holistic Health and Nature Scale, Pro-Nature Conservation Behavior Scale	Being outside in nature; social interaction; learning about using nature to alleviate stress	89% improved wellbeing (e.g., confidence, motivation, mood); 78% increased community connection; Self-reported decrease in stress, anxiety, and panic, calmer and more present, can better cope with problems; maintained wellbeing at follow-up
Bellotti et al. (2011); USA	Quantitative, pilot cohort study; psychometric tools	17; unemployed veterans, aged 24–57, 15 male; purposive sampling	Green jobs training program; wastewater management, recreation enhancement, habitat restoration; 2 days a week, 10 months	Pre-, Mid-, Post-; Beck Depression Inventory, Beck Anxiety Inventory, PTSD Checklist, Short Form Health Survey, Quality of Life Inventory	Peer support; spending time outdoors	Depression, anxiety, and PTSD reduced but not significantly. Significant increases in physical and social functioning.
Birch (2005); UK	Qualitative; observations, interviews, and notebook analysis	3; conservation group volunteers, aged 39–62, 2 female; opportunity sampling	Green gym; clearing brambles, preparing soil for nature garden, creating vegetable plots, planting trees, woodland rubbish clearance; 3 h weekly 10–14 weeks	Mid-; participant observations, semi-structured interviews, photographs taken by participants	Participating in achievable, tangible, and socially valued work; enjoyment; stimulation, sense of achievement; social teamwork	Positive effects on mental wellbeing, improved mental state, reduced stress, increased sense of achievement
Bond et al. (2019); AUS	Mixed methods, cross-sectional study; online surveys	2,453; Trees for Life non-profit organization members; purposive sampling	The tree scheme; volunteers grow seedlings for revegetation on rural land; duration not reported	Post-; online surveys to measure perceived benefits of the scheme	Teamwork; engaging with others; satisfying work; helping others, enjoyment, urban–rural connection	78% of volunteer growers reported participation as personally satisfying (including receipt of social benefits from participation, helping landholders, and working with family or others in a team) and enjoy the process of growing seedlings and developing their own capacity (knowledge and skills) through the activity

(Continued)

TABLE 1 (Continued)

Study (author, date; country)	Design (method; instruments)	Sample (n; characteristics; recruitment)	Pro-ecological intervention (program; activities [joint therapy]; duration)	Evaluation (time-points; measures)	Perceived therapeutic mechanisms	Key findings
Cardskadden and Lober (1998); USA	Mixed methods, case report; mail surveys	85; corporate employee volunteers; purposive sampling	Corporate wildlife habitat enhancement program; tree planting, creating nest boxes and wildflower meadows, wetland, and upland restoration; 13 h	Post-; mail surveys to measure perceived benefits of the program	Enhanced community contact	Program improved employee morale, pride, promoted self-motivation, and helped build stronger social (e.g., with community) relationships
Coventry et al. (2019); UK	Mixed methods, pilot study; interviews, surveys, and psychometric tools	45; conservation group volunteers, mean age 43.8, 59% male; opportunity sampling	Conservation volunteering; flood mitigation, scything, pruning, and creating wildlife habitats; 20–30 min	Pre, Post-; interviews, Short Warwick-Edinburgh Mental-Wellbeing Scale, Acute subjective Mood Adjective Checklist	Sense of belonging; social interaction; sharing aspirations; purposeful and meaningful work	Conservation work led to improvements in subjective wellbeing, mood, and stress. Work was perceived as purposeful and meaningful. Significant reduction in stress and increase in hedonic tone.
Finnegan (2016); UK	Qualitative; interviews	14; veterans with mixed physical disabilities, aged 23–62; 86% male; purposive sampling	Defense archeology group; surveying; geophysics and ordnance recovery; 10–14 days	Post-; interviews to measure perceived benefits and detrimental effects of the scheme	Sense of achievement; socialization opportunities; sense of appreciation	Veterans voiced improved self-esteem, self-worth, mood, and feelings of achievement
Fraser et al. (2009); USA	Qualitative; surveys and interviews	51; retired zoo volunteers, aged 55–76, most Caucasian; purposive sampling	Zoo volunteering; promoting conservation to visitors, conservation activities; duration not reported	Mid-; surveys and interview to measure motivations, experiences, and satisfaction with volunteering	Connection with nature; sense of self-purpose; value-expression	Participants reported improved self-esteem, gaining a sense of meaning and purpose, extending their social identity, and personal affirmation
Gagliardi et al. (2020); Italy	Mixed methods; focus groups and psychometric tools	19; mean age 75.7, 11 male, 68.4% lower education level; voluntary sampling	Civic environmental volunteering program; cleaning up areas, removing twigs along the trails, reporting hazards, maintenance and repair work in damaged areas or equipment; twice weekly session for one year	Pre-, Post-; focus groups, Positive and Negative Affect Schedule, Life Satisfaction Measure, Lubben Social Network Scale	Social factors; social bond formation; interacting with others; sense of belonging; making friends; being part of a group; relaxation	Positive variations were found in life satisfaction, affect and feelings of social support. Feeling of distress significantly decreased, alongside an increase in positive feelings. Participants reported making new friends, being a part of a group, getting one's mind off things, relaxing, having a sense of purpose, positivity, calmness, improved self-esteem. Reports of wider family noticing mood improvements.

(Continued)

TABLE 1 (Continued)

Study (author, date; country)	Design (method; instruments)	Sample (n; characteristics; recruitment)	Pro-ecological intervention (program; activities [joint therapy]; duration)	Evaluation (time-points; measures)	Perceived therapeutic mechanisms	Key findings
Gooch (2005); AUS	Qualitative; interviews	85; catchment group volunteers; purposive sampling	Catchment volunteering; natural resource management along the coast to combat land degradation; duration not reported	Mid-; interviews to measure experiences of the volunteering	Personal attachment; enjoyment; sense of belonging; sense of purpose; working toward a common goal	Volunteers felt empowered, balanced, and satisfaction. They expressed deep levels of satisfaction and felt valued by others in the group.
Hoffman (2020); USA	Mixed methods; surveys	17; 10 inmates, 7 community members; voluntary sampling	Community reintegration; orchard creation, tree planting; 5 h	Post-; survey to explore experiences	Social connectedness; feelings of belongingness; being outdoors; physical activity; enjoyment; building something positive for the community	Helped inmates with their spiritual and mental ability. Some reported it to be therapeutic. Perceptions of belongingness and connectedness to community also increased. Community members gained a better understanding of the inmates.
Hsiao et al. (2020); Taiwan	Quantitative, quasi-experimental longitudinal study; psychometric tools and medical records	72 ($n = 36$ recycling volunteers, $n = 36$ controls); mean age 71.5, 75% female; purposive and voluntary sampling	Tzu Chi recycling program; voluntary collecting, sorting, reclaiming reusable resources at recycling stations, making eco-friendly blankets for disaster survivors; at least 1 day per week	Pre-, Post-; Self-Compassion Scale, Compassion Scale, Geriatric Depression Scale, Chinese Hostility Inventory, Chinese Happiness Inventory, medical records	Working together to achieve a goal; sense of belonging; social inclusion; shared humanity; sense of achievement; expanding social circle; outdoor space and connection	Intervention had significant long-term effects (1 year period) in improving self-compassion and compassion for others, and happiness levels. Significant reductions in negative outcomes such as depression, hostility affect, and hostility suppression. Intervention helped build resilience for coping with life adversities. Control group reported decreased levels of self-compassion and happiness and maintained levels of depression.
Kogstad et al. (2014); Norway	Qualitative; interviews	9; non-school or work attending, aged 17–27; purposive sampling	Green care; weeding vegetable gardens, attending to and feeding animals; 2 months to 2 years	Post-; interviews to measure elements and achievements of the volunteering	Group atmosphere (safe, kind and honest); silence and acceptance in natural environments; not being judged	Reports of improved self-esteem, confidence and intervention helping with mental health problems.

(Continued)

TABLE 1 (Continued)

Study (author, date; country)	Design (method; instruments)	Sample (n; characteristics; recruitment)	Pro-ecological intervention (program; activities [joint therapy]; duration)	Evaluation (time-points; measures)	Perceived therapeutic mechanisms	Key findings
Koss (2010); AUS	Mixed methods; surveys	271; sea search volunteers, aged 18–71; mostly male; purposive sampling	Sea search volunteer program; teaches volunteers how to collect marine biota data using scientific methodologies, collected data contributes to coastline protection; duration not reported	Mid-; surveys to measure experiences, enjoyment, and wellbeing	Practical activity; outdoor activity; meaningful work; enjoyment; opportunity to socialize; belonging to a group; connecting with other like-minded people; sense of achievement	Volunteers gained a significant sense of enjoyment and achievement from participating and all strongly agreed that the activities generated personal satisfaction. Volunteers agreed that they felt good emotionally and mentally from carrying out marine activities.
Molsher and Townsend (2016); AUS	Mixed methods; interviews and psychometric tools	32; aged 14–72, 16 female, 10 unemployed, 5 with MH difficulties; purposive sampling	Get dirty feel good program; cockatoo recovery, koala management, seagrass monitoring, dolphin surveys, sea lion conservation, marine debris collection and weed management; 9–10 weeks, 5 h per week	Pre-, Post-, 3 m Follow-up; interviews explored experiences, General Wellbeing Scale, Emotional State Scale	Group dynamic; learning skills; social connectedness; work to help	Participants experienced positive emotional shifts during activities (>60% of mood parameters improved). General wellbeing significantly improved and tended to remain high at follow-up.
Moore et al. (2006); AUS	Mixed methods; interviews, surveys, and psychometric tools	102 ($n = 51$ community land management volunteers, $n = 51$ controls); most aged 45–64, 61 males; purposive and voluntary sampling	Community land management; protecting biodiversity, preserving native flora and fauna; average membership 7 years	Mid-; interviews to assess wellbeing, surveys to assess anxiety and depression, Community Cohesion Scale	Increased social networks; feelings of belonging; enjoyment; developing skills	Land management volunteers reported experiencing higher levels of mental wellbeing than controls. Many indirect benefits reported by volunteers, such as pleasure, enjoyment, and a sense of belonging to one's community.
O'Brien et al. (2010); UK	Mixed methods; interviews, surveys, and psychometric tools	88; aged 16–76, 91% white British; purposive sampling	Environmental volunteering program; tree planting, vegetation clearance, removal of invasive species, sapling removal, tree thinning; 3 weeks	Pre-, Post-; interviews to measure experiences of volunteering, survey to assess wellbeing, Emotional State Scale, Personal Wellbeing Index	Contributing meaningfully to local community; building social networks; physical activity; being outdoors; sense of achievement; mental stimulation	Volunteers reported reductions in stress and mental fatigue and experienced a statistically significant positive emotional shift. Gained satisfaction with making a meaningful contribution to society and local communities. Found volunteering activities as therapeutic, mentally stimulating, and provided a sense of calmness and achievement. 21% experienced a negative change in general emotional states such as dissatisfaction and boredom.

(Continued)

TABLE 1 (Continued)

Study (author, date; country)	Design (method; instruments)	Sample (n; characteristics; recruitment)	Pro-ecological intervention (program; activities [joint therapy]; duration)	Evaluation (time-points; measures)	Perceived therapeutic mechanisms	Key findings
O'Brien et al. (2011); UK	Qualitative; interviews	88; aged 16–76, 72% male, all white, mixed socioeconomic backgrounds, 25% marginalized; purposive sampling	Environmental volunteering program; general conservation activities; 10 h or less per month	Mid-; interviews to measure experiences of volunteering	Engaging in meaningful work; conserving nature; adding meaning to life; being outdoors in fresh air; enjoyment; learning; discovering new places	Volunteers reported improved wellbeing, improved relationships with others and family, better integration with community, and growing independence.
Pálsdóttir et al. (2014); Sweden	Mixed methods; interviews and psychometric tools	21; professionals with work stress; aged 29–68, 19 female, high education, homeowners; cluster sampling	Nature-based vocational rehabilitation; horticulture activities [alongside relaxing exercise, psychiatrist meetings]; 12 weeks, 3.5 h, 4 days per week	Pre-, Post-, 1y Follow-up; Stress and Crisis Inventory, Sense of Coherence Scale	Contact with nature; learning; creativity	Following intervention, participants reported significantly decreased stress. Contact with nature was reported as restorative and eased their minds.
Pillemer et al. (2010); USA	Quantitative, longitudinal cohort comparison study (1974–1994); surveys and psychometric tools	2,630 ($n = 155$ environmental volunteers); cohort mean age 44.7, 56.9% female; purposive sampling	Environmental volunteering; watershed monitoring, ecological restoration, environmental stewardship; 20 years	Mid-, 20y Follow-up; general wellbeing Likert scales and questions about environmental volunteering, Perceived Health Scale, Depression Scale	Not reported	Engagement as an environmental volunteer at baseline was significantly associated with reduced odds of perceiving oneself in fair or poor health, and reduced odds of experiencing depressive symptoms. Longitudinal analyses demonstrated a positive effect of both environmental volunteering.
Power and Smyth (2016); UK	Qualitative; focus groups and interviews	18; heritage conservation volunteers, aged 30s–70s, 14 females; purposive sampling	Preserving place; community heritage conservation, preserving local and historical assets from harm; duration not reported	Post-; interviews and focus groups exploring motivations, project origins, social impacts, and everyday experiences	Building new connections and friendships; socializing; learning	Intervention greatly benefited volunteers' social wellbeing by helping them to build a wider social network and feelings of togetherness
Puhakka et al. (2019); Finland	Qualitative; surveys and interviews	74 ($n = 49$ parents, $n = 25$ day-care personnel) reporting wellbeing and play of children aged 3–5; purposive sampling	Green yards; children engaged in nature-based activities, looked after plants and vegetation, planted vegetables and flowers, watered forest floor mat and sod; 1 month	Post-; surveys and interviews exploring children's activity, excitement, and wellbeing	Involvement in care; nature exploration; pleasant activities; time outdoors; physical activity; multi-sensory experiences; learning skills	The green yard activities had positive impacts on children's and adults' moods, wellbeing, energy, and motivation. Increased sense of community was reported by staff and children were enthusiastic to take care of plants.

(Continued)

TABLE 1 (Continued)

Study (author, date; country)	Design (method; instruments)	Sample (n; characteristics; recruitment)	Pro-ecological intervention (program; activities [joint therapy]; duration)	Evaluation (time-points; measures)	Perceived therapeutic mechanisms	Key findings
Reynolds (2000); UK	Mixed methods; interviews and psychometric tools	15; aged 40–73, 8 male, 82% retired; voluntary sampling	Green gym; clearing overgrown vegetation, making room for rare species, building stiles, coppicing, planting trees, hedge laying; 2 months, twice a week	Pre-, Post-; interview about volunteering experiences, Medical Outcomes Trust Short Form	Meaningful work; being outdoors in the countryside; meeting other people	Volunteers reported improved quality of life, improved psychological wellbeing, and increased pleasure and satisfaction from doing something meaningful.
Richardson et al. (2016); UK	Quantitative; online surveys	126; aged 22–71, 15 males; voluntary sampling	30 days wild 2015 campaign; avoiding use of pesticides, leaving a patch of grass to grow long, alerting representatives to wildlife issues; 30 days	Pre-, Post-, 2 m Follow-up; survey exploring connection to nature, pro-nature behaviors, health, and wellbeing	Connection to nature; facilitating exercise; social contact; sense of purpose	Campaign found increases in participants connection to nature, and improved health, happiness, and wellbeing. Improvements sustained at follow-up.
Richardson et al. (2018); USA	Quantitative; online surveys and psychometric tools	380; mean age 49.5, 48 males, 93% white; voluntary sampling	30 days wild 2017 campaign; avoiding use of pesticides, leaving a patch of grass to grow long, alerting representatives to wildlife issues; 30 days	Pre-, Post-, 2 m Follow-up; survey exploring connection to nature, pro-nature behaviors, health, and wellbeing, Inclusion of Nature in Self Scale, Engagement with Beauty Scale, Difficulties in Emotion Regulation Scale	Connection to nature; noting natures beauty	Significant increases in wellbeing, in terms of happiness, were found from pre- to post-participation. Improvements in wellbeing were sustained at follow-up
Sobko et al. (2020); Hong Kong	RCT; surveys and psychometric tools	54 ($n = 30$ intervention, $n = 24$ controls); aged 2–5; voluntary sampling	Play&Grow program; children interacted with natural outside world, growing plants, caring for plants outside; 1 session per week, 10 weeks	Pre-, Post-; Children's Stress Questionnaire, Connectedness to Nature	Connectedness to nature; interaction with nature	The intervention showed improved pro-social behavior and psychosocial wellbeing. Overall perceived stress significantly reduced, particularly anger frequency, among preschool children. Increased connectedness to nature following intervention.
Takase et al. (2019); Japan	Quantitative; online surveys	1,444; conservation volunteers, aged 20s–60s; 50% female; voluntary sampling	Conservation activities; duration not reported	Post-; survey exploring conservation experiences and motivations	Interaction with other people	Healing (improvement of mental wellbeing) rated as significant motivator (81% agreed). Social welfare rated as a key motivator (74% agreed). Improvement of mental wellbeing and wellbeing for local community, and interaction with other people also key motivators.

(Continued)

TABLE 1 (Continued)

Study (author, date; country)	Design (method; instruments)	Sample (n; characteristics; recruitment)	Pro-ecological intervention (program; activities [joint therapy]; duration)	Evaluation (time-points; measures)	Perceived therapeutic mechanisms	Key findings
Tashiro (2022); Japan	Mixed methods; surveys and interviews	109; aged 18–80, 51% female, 50% unemployed; purposive sampling	Green management of rural region following post-disaster; planted camellia trees, picked up garbage, planted flowers along the road; duration not reported	Post-; survey and interview exploring perceived benefits, barriers, and green self-efficacy	Gifting future generations; social cohesion; helping local landscapes	Many agreed that participating in green activities promoted their self-worth. Green management induced hedonic experiences and promoted social cohesion.
Tharrey et al. (2020); France	Mixed methods; interviews, surveys, and psychometric tools	132 ($n = 66$ community gardeners, $n = 66$ matched controls), mean age 44, most female, educated; purposeful sampling	Community garden; caring for plants and plots; 8 months	Pre-, Post-; interviews exploring lifestyle changes, Warwick-Edinburgh Mental Wellbeing Scale, UCLA Loneliness Scale	Not reported	No significant statistical differences between participation and controls on mental wellbeing, social health, or connection to nature. Some participants reported strong or slight increases in life satisfaction and social relations.
Townsend (2006; Study 1); AUS	Qualitative; interviews	11; reserve management volunteers; purposive sampling	Friends of Damper Creek; management and maintenance of a small linear park; mostly weekends	Mid-; interviews exploring motivations and benefits of volunteering	Engaging in meaningful activities; building satisfactory relationships; nature contact; creative expression; positively contributing to society	Volunteers reported reduced stress, a greater sense of belonging and connectedness, and a widening of the social circle of children and families through membership. Mental and spiritual wellbeing from shared fun with others.
Townsend (2006; Study 2); AUS	Qualitative; interviews and surveys	18; residents volunteering to protect park from commercial sale; purposive sampling	Truganina explosives reserve preservation program; planning, developing and maintenance of nature reserve; mostly weekends	Mid-; interviews and surveys exploring involvement, health and wellbeing, and social capital and connectedness	Engaging in meaningful activities; building satisfactory relationships; nature contact; creative expression; positively contributing to society	Members perceived significant benefits relating to wellbeing: increased satisfaction stemming from doing something purposeful, mental relaxation, enjoyment, felt sense of accomplishments, and relief from outside pressures.
Townsend (2006; Study 3); AUS	Mixed methods; interviews, surveys, and psychometric tools	102 ($n = 51$ community conservation volunteers, $n = 51$ matched controls); purposive and voluntary sampling	Trust for nature; community-based conservation; protection of private land of high conservation value; mostly weekends	Mid-; interviews and surveys exploring, health, wellbeing, and social involvement, Neighborhood Cohesion Scale	Engaging in meaningful activities; building satisfactory relationships; nature contact; creative expression; positively contributing to society	Compared to controls, volunteers had perceived their health as better, and felt a greater sense of belonging in their communities.

(Continued)

TABLE 1 (Continued)

Study (author, date; country)	Design (method; instruments)	Sample (n; characteristics; recruitment)	Pro-ecological intervention (program; activities [joint therapy]; duration)	Evaluation (time-points; measures)	Perceived therapeutic mechanisms	Key findings
Weston et al. (2015); Ghana	Mixed methods; focus groups and surveys	238 ($n = 134$ focus groups, $n = 104$ surveys with natural regeneration volunteers); purposive sampling	Farmer-managed natural regeneration; voluntary adding and managing trees and shrubs in farmlands or pastures; duration not reported	Post-; focus groups and surveys about the impact of the program on people's lives	Optimism; community connection; community unity	Intervention boosted optimism of both participants and local community. It increased feelings of community unity. Improved psychosocial wellbeing (creation of aesthetically pleasing and comfortable environment), joy, and peace of mind stemming from intervention.
Wilkie and Michialino (2014); France	Quantitative; surveys and psychometric tools	73 ($n = 43$ community engaged residents, $n = 30$ non-engaged controls); mean age 47, 64% female; 58% unemployed; purposive sampling	Community engaged residents; pro-ecological activities, regeneration, or maintenance of public spaces; some regeneration projects done 10 years ago	Follow-up; surveys exploring life satisfaction, Personal Wellbeing Index, Social Cohesion Subscale	Social cohesion	Participative co-production had long-term benefits, including enhanced life satisfaction. Residents in areas with a strong participative co-production felt greater social cohesion.
Wilson et al. (2009); UK	Mixed methods; interviews, focus groups, and psychometric tools	77; aged 21–61, 20 females, all had history of MH problems; purposive sampling	Conservation program; removing unwanted tree seedlings, transplanting oak trees, construction using natural materials; 12 weeks	Pre-, Post-; interviews and focus groups explored experiences and attainments, Mental Component Summary Scale, SF-12 Health Scale, Warwick-Edinburgh Mental Wellbeing Scale	Engaging with nature; community engagement; social inclusion; meaningful work; sense of purpose; daily routine; leaning skills	Participants reported improvements to mental wellbeing through increasing confidence and self-esteem. No statistically significant difference between pre- and post-intervention on mental wellbeing scales.
Yerrell (2008); UK	Quantitative; surveys and psychometric tools	194; aged 25–64, 60% males, 71% unemployed; purposive sampling	Green gym; improving green spaces, gardening work, planting seeds, watering plants; minimum 3 months	Pre-, Post-; survey exploring motivations and benefits, Mental Component Summary Scale SF-12 Health Scale	Daily activity; exercise; being outdoors; improving the environment	Improvements in mental health following intervention. 99% either strongly agreed or agreed that improvements in mental wellbeing and confidence are key benefits gained from participating in the Green Gym. Personal achievement and positive self-worth reported.

TABLE 2 Study designs and quality assessments.

Study	Methods	Score	Criteria*				
Qualitative studies			1.1	1.2	1.3	1.4	1.5
Birch (2005)		80%	✓	?	✓	✓	✓
Finnegan (2016)		100%	✓	✓	✓	✓	✓
Fraser et al. (2009)		100%	✓	✓	✓	✓	✓
Gooch (2005)		80%	✓	✓	✓	✗	✓
Kogstad et al. (2014)		80%	✓	✓	✓	✓	✗
O'Brien et al. (2011)		100%	✓	✓	✓	✓	✓
Power and Smyth (2016)		100%	✓	✓	✓	✓	✓
Puhakka et al. (2019)		100%	✓	✓	✓	✓	✓
Townsend (2006; Study 1)		20%	✓	✗	?	?	✗
Townsend (2006; Study 2)		40%	✓	✓	?	?	✗
Quantitative randomized controlled trials			2.1	2.2	2.3	2.4	2.5
Sobko et al. (2020) 		80%	✓	✓	✓	?	✓
Quantitative non-randomized studies			3.1	3.2	3.3	3.4	3.5
Hsiao et al. (2020) 		100%	✓	✓	✓	✓	✓
Pillemer et al. (2010) 		80%	✓	✓	✓	✓	?
Quantitative descriptive studies			4.1	4.2	4.3	4.4	4.5
Bellotti et al. (2011)		100%	✓	✓	✓	✓	✓
Richardson et al. (2016)		80%	✓	✓	✓	✗	✓
Richardson et al. (2018)		80%	✓	✓	✓	✗	✓
Takase et al. (2019)		80%	✓	✓	✓	?	✓
Wilkie and Michialino (2014) 		100%	✓	✓	✓	✓	✓
Yerrell (2008)		80%	✓	✓	✓	✗	✓
Mixed methods studies			5.1	5.2	5.3	5.4	5.5
Asah and Blahna (2013)		60%	✓	✓	✓	?	✗
Avon Wildlife Trust (2021)		40%	✓	✗	✓	✗	✗
Bond et al. (2019)		80%	✓	✓	✓	✓	✗
Cardskadden and Lober (1998)		60%	✓	✓	✗	✓	✗
Coventry et al. (2019)		100%	✓	✓	✓	✓	✓
Gagliardi et al. (2020)		80%	✓	✓	✓	✓	✗
Hoffman (2020)		60%	✓	✗	✓	✓	✗
Koss (2010)		80%	✓	✓	✓	✓	✗
Molsher and Townsend (2016)		40%	✓	✓	✗	✗	✗

(Continued)

TABLE 2 (Continued)

Study	Methods	Score	Criteria*				
			1.1	1.2	1.3	1.4	1.5
Moore et al. (2006) 	  	60%					
O'Brien et al. (2010)	  	100%					
Pálsdóttir et al. (2014)	 	100%					
Reynolds (2000)	 	60%					
Tashiro (2022)	 	80%					
Tharrey et al. (2020) 	  	60%					
Townsend (2006; Study 3) 	  	80%					
Weston et al. (2015)	 	60%					
Wilson et al. (2009)	  	100%					

-  met criteria;
-  did not meet criteria;
-  unclear if criteria met (*see [Supplementary Appendix C](#) for criteria);
-  comparison study;
-  surveys;
-  interviews;
-  psychometric tools;
-  focus groups;
-  observations.

3.4 Review question 3: Evaluation and outcome measures

Most studies used surveys (62%) and interviews (59%) to collect evaluation data, and many (43%) utilized psychometric tools. Most studies collected data at one time-point only (57%), either at mid-intervention ($n=9$), post-intervention ($n=11$) or follow-up ($n=1$). Fifteen studies (27%) collected data at pre- and post-intervention, and five (14%) also collected data at follow-up (see [Figure 4](#)). Most (43%) follow-up measures were collected 2–3 months after the intervention, though one was collected at 12, and one at 24 months. Two longitudinal studies analyzed follow-up data, one at 10 years after a neighborhood regeneration project ([Wilkie and Michialino, 2014](#)), and one at 20 years in a cohort comparison study ([Pillemer et al., 2010](#)).

Most of the 18 studies using validated psychometric tools used 1–2 measures relating to mental wellbeing, except three that used 3–4 measures. Fourteen studies used psychometric tools reliably, taking pre- and post-measures, with four of these also collecting follow-up measures. These 14 studies largely applied within-group analysis, with three also applying between-group analysis where a comparison group was included. The remaining four studies used psychometric tools less reliably, opting for single time-point measurement for between-group comparison.

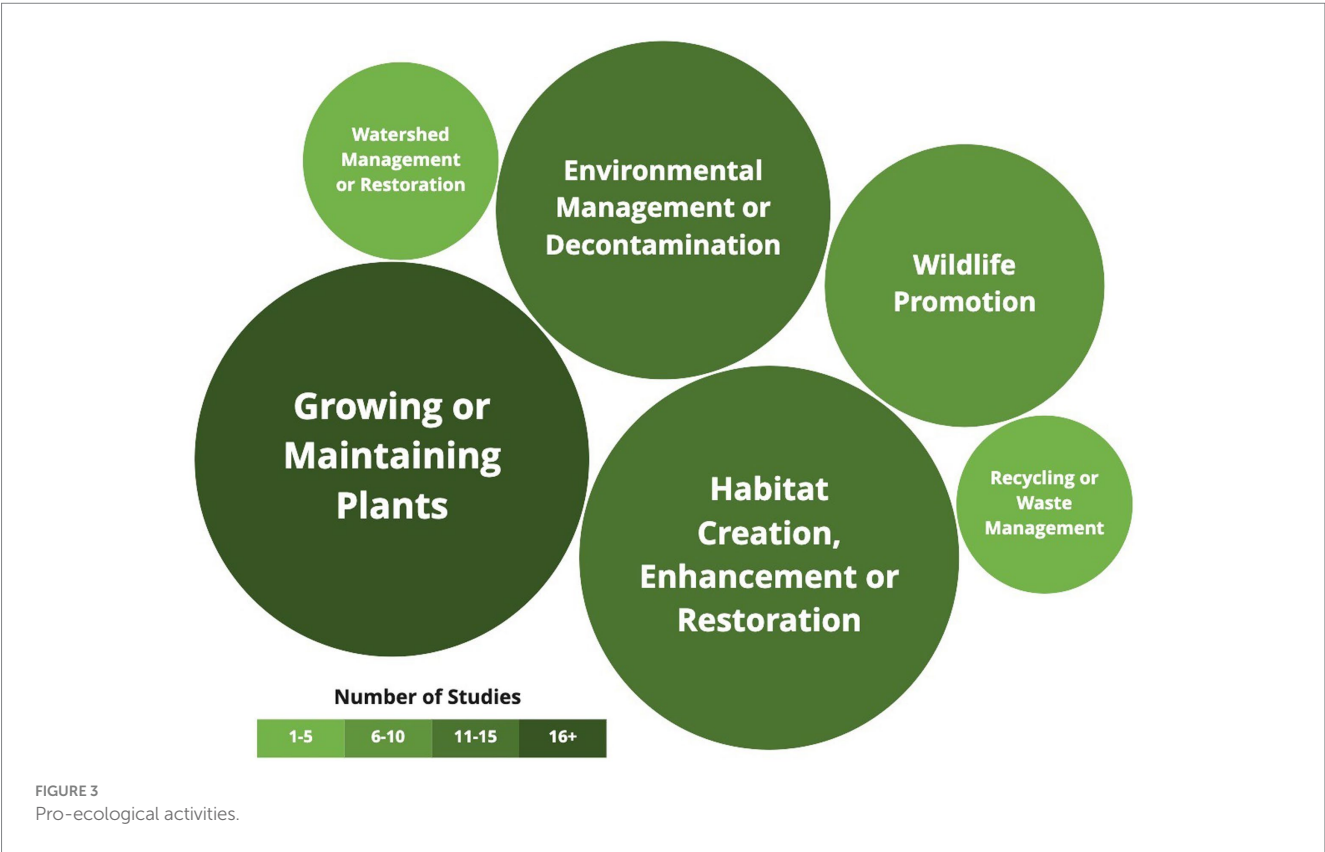
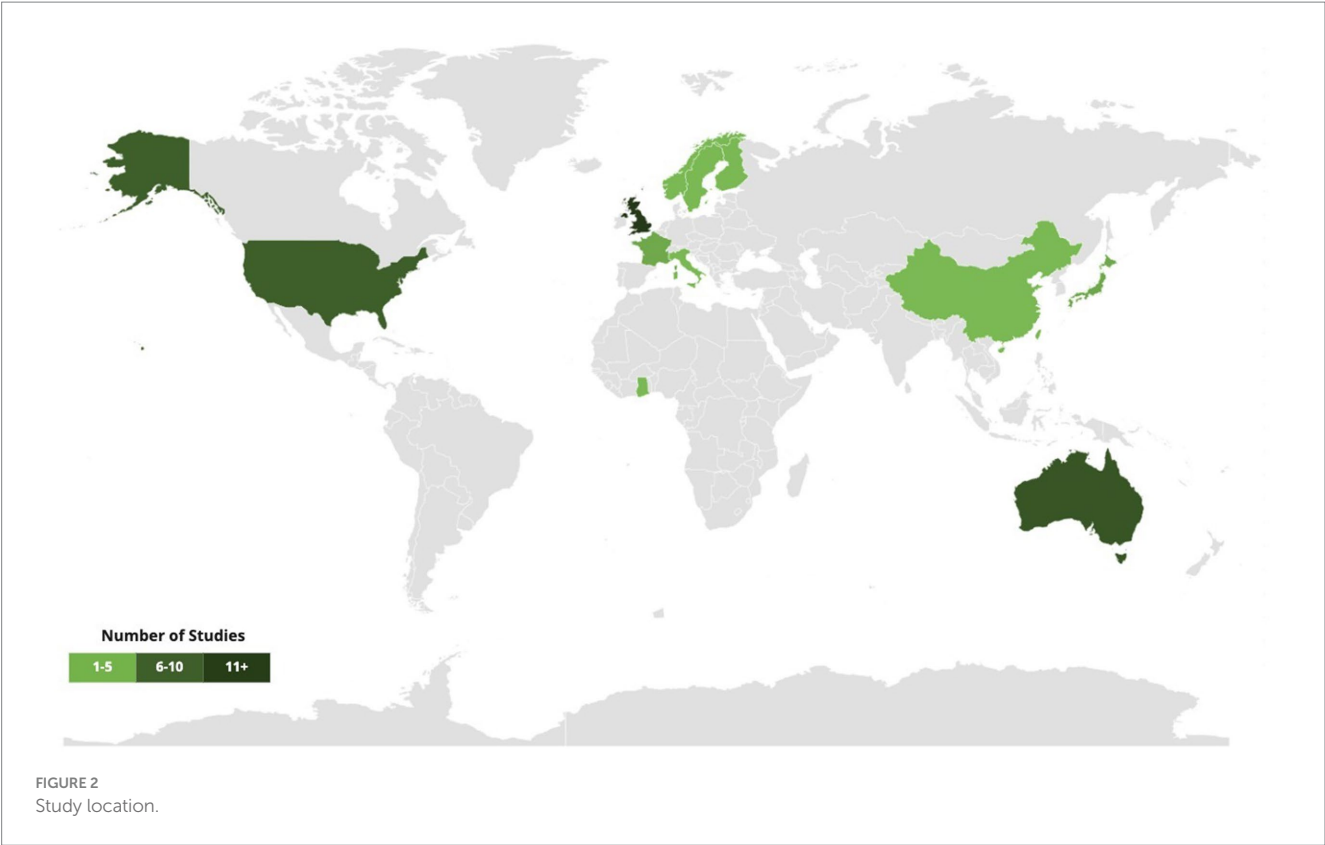
The types of psychometric tools used are shown in [Figure 5](#). Many used measures that assessed mental health or wellbeing, with the most used being the Warwick-Edinburgh Mental Wellbeing Scales (WEMWBS) and mental components from the 36-Item Short Form Survey (SF-36). Some studies used culturally specific scales (e.g.,

Chinese Happiness Inventory; [Hsiao et al., 2020](#)), and age-specific scales (e.g., Lubben Social Network Scale; [Gagliardi et al., 2020](#)).

3.5 Review question 4: Indications of perceived therapeutic mechanisms

Analysis of the efficacy or effectiveness of the interventions was outside the scope of this review; however, it is worth noting that nearly all studies reported positive outcomes in either participant mental wellbeing, mood, or distress reduction. Discussion about the perceived or hypothesized therapeutic mechanisms was found in almost all (95%) of the studies (see [Figure 6](#)). Most studies (68%) reported social factors, including social interaction (24%), building social networks (24%), social inclusion (22%), and teamwork (14%). Factors relating to the nature of the activity were commonly reported (54% of studies), including participants feeling that the work was meaningful (38%), was helping others or the landscape (8%), was contributing to society (8%), and gave them a sense of purpose (8%).

Physical factors were commonly cited as therapeutically influential (54% of studies), including contact with nature (32%), being outdoors (27%), and exercise (19%). Personal factors were reported just as frequently (54% of studies), including learning new skills (22%), enjoyment (22%), as well as gaining self-efficacy and a sense of achievement (14%), and opportunity for creative expression (11%). Additionally, many studies (38%) discussed community factors, including community cohesion and connection (22%), and a sense of belonging (22%).



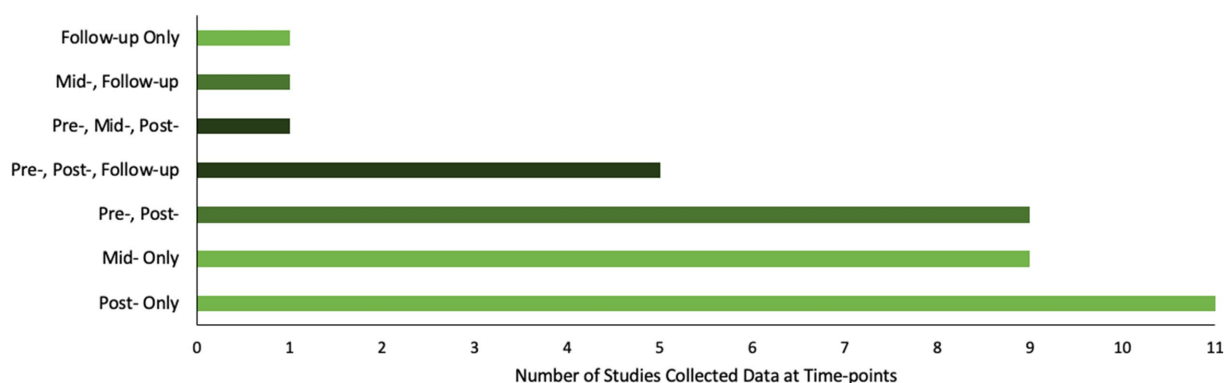


FIGURE 4
Data collection time-points.

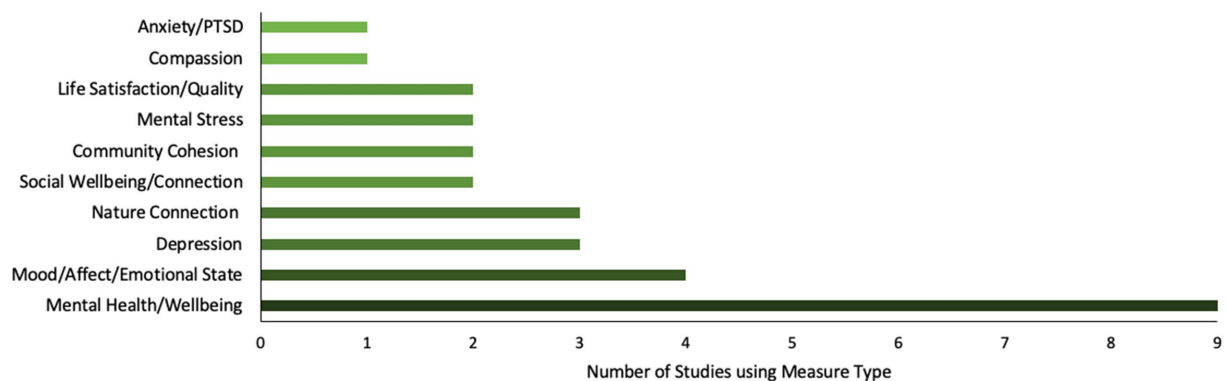


FIGURE 5
Types of outcome measures used.

3.6 Review question 5: Indications of acceptability and challenges

Explicit indications of the acceptability of the interventions were found in only eight studies (22%), all of which cited challenges regarding the activities or the sustainability of programs. For example, the positive therapeutic impact relating to social factors was tempered by reports of interpersonal conflict within groups in four studies. Additionally, two studies reported problems with running activities in bad weather conditions, two reported time constraints as barriers to participation, and two mentioned sustainability issues due to funding or lack of leadership.

Four of these eight studies made positive references about acceptability, with two studies reporting that participants would continue the activities long-term, and one reporting that the intervention provided a “steppingstone” to further community engagement (Wilson et al., 2009).

3.7 Review question 6: Indications of eco-related distress

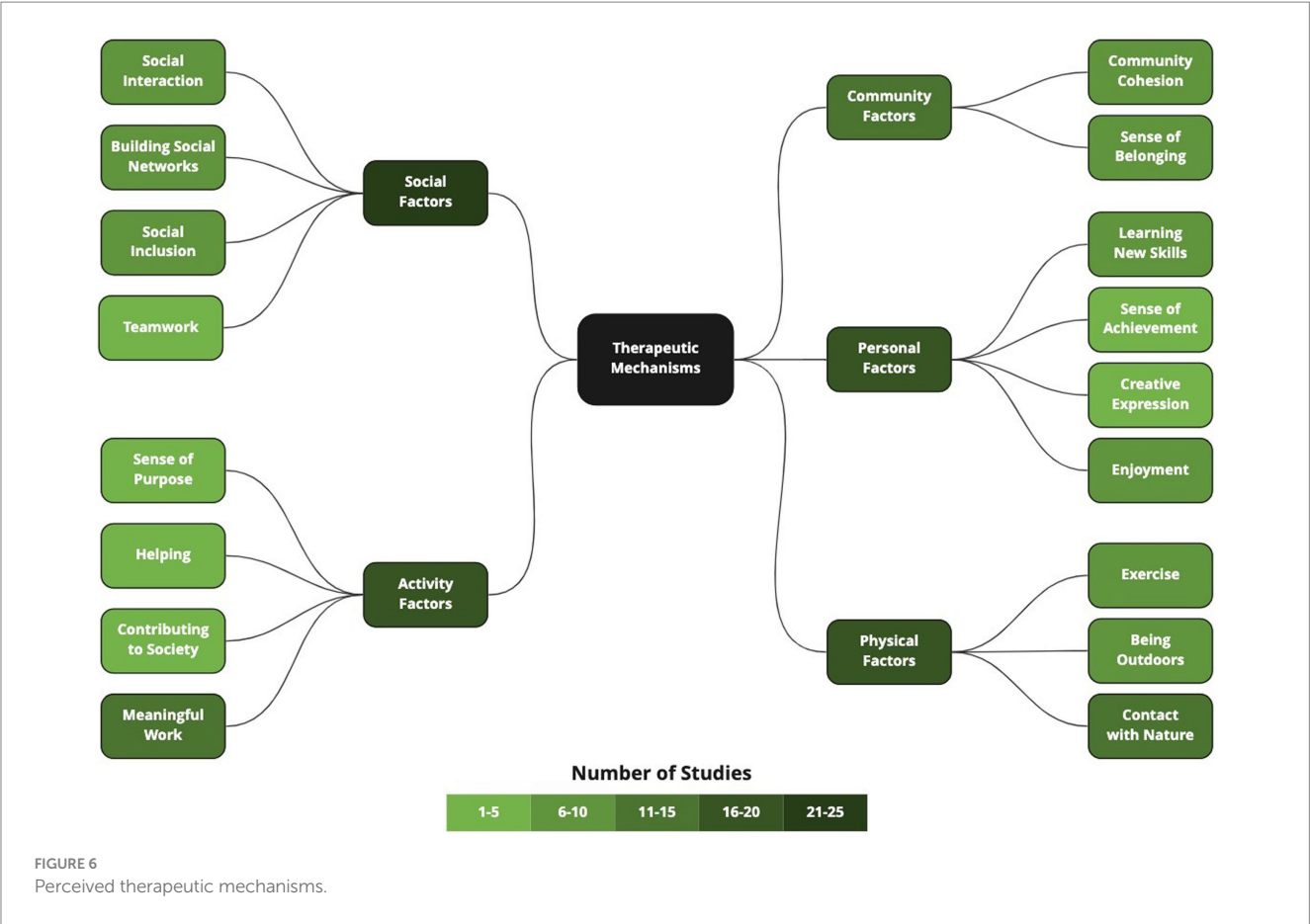
Given the relatively recent interest in researching eco-related distress, perhaps it is unsurprising that none of the studies explicitly measured or referenced eco-distress. However, nearly a third (30%) of

the studies reported either participant concerns, views, or intended changes relating to the environment following the activities. For instance, one study reported that participants had expressed concerns about animals going extinct within local environments, which made them feel that longer-term volunteering commitment was needed despite the immediate gratification from the activity (Gooch, 2005). Two studies (O’Brien et al., 2011; Molsher and Townsend, 2016) reported that participants had gained awareness or understanding of issues in the environment and the need to conserve it from participation.

Six studies reported ecological attitude or behavior changes, largely through qualitative feedback. For instance, some participants reported that they had adopted pro-environmental behaviors or commitments following the intervention in three studies (e.g., “recycling,” Avon Wildlife Trust, 2021; “environmental activism,” Fraser et al., 2009). In the other three, some participants reported that they had adopted pro-environmental attitudes or beliefs (e.g., “developing environmental respect,” O’Brien et al., 2011).

4 Discussion

This novel and timely systematic scoping review has assessed current evidence for pro-ecological group-based community activities and their influence on mental wellbeing. Much like was found by



Husk et al. (2016), studies reported a broad range of pro-ecological interventions, delivered in different ways over different durations, evaluated using varying study designs and assessment methods. Acceptability and challenges about the interventions were mentioned in several studies, and conclusions are mixed, given the considerable variation in activities studied and methodological quality. A full synthesis of the literature proved challenging, in part due to the decision to keep the scope broad to capture a diverse range of literature, including people across the lifespan and the globe.

Given this heterogeneity of the studies, and their variable quality and methods, synthesis and evaluation of wellbeing outcomes were neither planned nor attempted. Nonetheless, it is worth noting that key findings from almost all studies (see Table 1) reported positive outcomes in either participant mental wellbeing, mood, or distress reduction. It is reasonable to propose, then, that the common theoretical therapeutic mechanisms are more important than the discrete factors, duration, and location of the group-based pro-ecological activities.

Indeed, despite variations in activity types, samples, locations, and durations of participation, there are clear common findings and themes across studies which may relate to perceived therapeutic mechanisms, warranting further investigation and better experimental research designs. Social factors and perhaps distinguishing features of the pro-ecological activities appear to play an important role. Essentially, it seems that the activities bring people together socially, enabling them to work collaboratively on something that is meaningful and helpful to society at large. People thus talked about gaining a sense

of belonging, purpose, and achievement. This fits with several theories including the Main Effect Model (Rook, 1990), which focuses on the rewarding nature of social integration through belonging and purpose, and the Warm-Glow Theory (Andreoni, 1989), which considers personal satisfaction and joy as arising from helping others or the environment. Where reduced distress was also reported, the Stress-Buffering Model (Cohen and Wills, 1985) could explain this through the stress coping mechanism believed to arise from social connection, and the Negative-state Relief Model (Cialdini and Kenrick, 1976), where pro-social actions may lead to improved mood.

Many activities were described as enjoyable, allowing people to learn alongside benefiting from exercise and being outdoors in nature. These findings are supported by existing theoretical approaches including the benefits nature can have upon stress (e.g., Stress Reduction Theory; Ulrich et al., 1991), and the sense of mastery and confidence arising from engaging in meaningful activity (e.g., Self-Efficacy Hypothesis; Craft, 2005). Moreover, longitudinal studies have implicated the importance of learning new skills for life satisfaction, self-esteem, and self-confidence (Feinstein and Hammond, 2004).

Given the blend of potential therapeutic mechanisms, and this review indicating broad improvement to mental wellbeing across ages and world locations, “eco-caring together” activities may offer something unique that requires further high-quality research. Many individual theories exist that attempt to explain the benefits of the isolated elements of the activities (e.g., exercise, pro-social behavior), but it is the compounding effect of these elements in a single activity

that is intriguing, calling for synthesis and development of new theory. This scoping review provides a sound foundation and recommendation for further enquiry into the effectiveness and efficacy of such activities to promote mental health and wellbeing for a wide range of people across the world.

Just as Husk et al. (2016) recommended previously, more robust research is still needed. Randomized controlled designs could provide more valid evidence of the efficacy and effectiveness of such interventions. For instance, such trials could explore whether brief pro-ecological group-based interventions lead to substantive, sustained wellbeing improvements. If so, there may be the hope of such interventions being configured into non-clinical treatment programs that can be prescribed. Future research should examine what elements of the activities work for who, and the impact of individual characteristics on the benefits gained from participation. Comparisons between individual and collectivist societies would also be interesting.

An unforeseen finding was that some studies reported the activities increasing pro-ecological awareness (i.e., understanding, attitudinal, or behavioral changes) in some participants. This is promising, as it suggests that such activities could offer a way of engaging communities in direct, and ongoing indirect, benefits to ecological health. In the context of the ecological crisis, Empowerment Theory (Perkins and Zimmerman, 1995) posits that feelings of empowerment can enhance member participation and improvement of goal attainment. If this is the case, perhaps “eco-caring together” activities hold a self-motivating and self-sustaining potential for both personal and planetary health. However further research may also like to consider whether developing awareness of issues relating to planetary health could also lead to increased levels of eco-distress in some populations, and if so, explore wise and meaningful ways of incorporating this into new interventions.

4.1 Strengths and limitations

This scoping review was planned with the full protocol published prior to searching, making it transparent, clear, and open. A significant strength is its breadth, searching for sources across both published peer-reviewed and gray literature. For instance, reports from third-sector charities were found to meet eligibility criteria (e.g., Avon Wildlife Trust, 2021). This allowed this review to break from constraints to gain a fuller sense of what, where, why, and how “eco-caring together” is happening, and with who involved. This innovative review thus brings together diverse and varied literature, offering an integration of helpful theoretical approaches to understanding mental health, wellbeing, nature-based, group-focused, pro-ecological activities.

Such breadth and flexibility bring concurrent limitations. The inclusion of some non-academic sources (and thus the lack of peer-review) means caution had to be taken when interpreting findings, and the potential bias that could have arisen relating to funding ambitions. Dissertations were not included in the search strategy, and although this could have potentially led to the exclusion of relevant studies, the final included studies do still offer a comprehensive overview of the current state of the literature which has been subjected to the rigors of peer-review. The heterogeneity across samples, activities, and evaluation methods does however limit the degree to

which an over-arching synthesis is possible, and thus conclusions about potential efficacy or effectiveness. All papers screened were in English meaning no papers were excluded on this criterion, which may have introduced publication bias.

We urgently need to find novel and scalable interventions to tackle the mental health crisis, and engaging people in activities that support planetary health offers an approach that can equally address the current ecological and climate crises. This scoping review paints a promising picture for pro-ecological group-based community interventions for mental health, wellbeing, and ecological health. A systematic approach to developing a stronger evidence base is encouraged, as well as a future systematic review of the efficacy and effectiveness of “eco-caring together” activities for mental wellbeing.

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

KB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. EM: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – review & editing. BC: Data curation, Formal analysis, Investigation, Validation, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. KB was a trainee clinical psychologist enrolled on the DClinPsy program at the University of Bath funded by NHS Higher Education England. EM was an academic staff member on the DClinPsy program at the University of Bath and supervised KB. BC was an undergraduate student at the University of Bath who offered assistance. This report was independent research.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product

that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Author disclaimer

The views expressed in this publication are those of the authors and not necessarily those of the University of Bath, NHS, or the Department of Health and Social Care. No other external or grant

funding was used for this review. Sources of funding for the included studies can be found in [Supplementary Appendix D](#).

Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1288791/full#supplementary-material>

References

- Albright, E. A., and Crow, D. (2019). Beliefs about climate change in the aftermath of extreme flooding. *Clim. Chang.* 155, 1–17. doi: 10.1007/s10584-019-02461-2
- Andreoni, J. (1989). Giving with impure altruism: applications to charity and Ricardian equivalence. *J. Polit. Econ.* 97, 1447–1458. doi: 10.1086/261662
- Asah, S. T., and Blahna, D. J. (2013). Practical implications of understanding the influence of motivations on commitment to voluntary urban conservation stewardship. *Conserv. Biol.* 27, 866–875. doi: 10.1111/cobi.12058
- Avon Wildlife Trust (2021). *Wellbeing with nature evaluation report: Improving people's health and wellbeing, whilst caring for the natural environment and deepening their connection to nature*. Available at: https://www.tnlcommunityfund.org.uk/media/insights/documents/Wellbeing-with-Nature-Evaluation-Report_-June-2021_-10271074-1.pdf?mtime=20210708104603&focal=none
- Bellotti, C., Laffaye, C., Weingardt, K. R., Fischer, M., and Schumacher, T. (2011). Re-visioning veteran readjustment: evaluating outcomes of a green-jobs training program. *J. Vocat. Rehabil.* 35, 51–57. doi: 10.3233/JVR-2011-0553
- Birch, M. (2005). Cultivating wildness: three conservation volunteers' experiences of participation in the green gym scheme. *Br. J. Occup. Ther.* 68, 244–252. doi: 10.1177/030802260506800602
- Bond, A. J., Saison, C. L. A., Lawley, V. R., and O'Connor, P. J. (2019). Bridging the urban-rural divide between ecosystem service suppliers and beneficiaries: using a distributed community nursery to support rural revegetation. *Environ. Manag.* 64, 166–177. doi: 10.1007/s00267-019-01179-2
- Bragg, R., and Atkins, G. (2016). *A review of nature-based interventions for mental health care*. Natural England Commissioned Reports, Number 204.
- Breed, M. F., Cross, A. T., Wallace, K., Bradby, K., Flies, E., Goodwin, N., et al. (2020). Ecosystem restoration: a public health intervention. *EcoHealth* 18, 269–271. doi: 10.1007/s10393-020-01480-1
- Cardskadden, H., and Lober, D. J. (1998). Environmental stakeholder management as business strategy: the case of the corporate wildlife habitat enhancement programme. *J. Environ. Manag.* 52, 183–202. doi: 10.1006/jema.1997.0170
- Capstick, S., Nash, N., Whitmarsh, L., Poortinga, W., Haggard, P., and Brügger, A. (2022). The connection between subjective wellbeing and pro-environmental behaviour: individual and cross-national characteristics in a seven-country study. *Environ Sci Policy* 133, 63–73. doi: 10.1016/j.envsci.2022.02.025
- Chatterjee, H. J., Camic, P. M., Lockyer, B., and Thomson, L. J. (2018). Non-clinical community interventions: a systematised review of social prescribing schemes. *Arts Health* 10, 97–123. doi: 10.1080/17533015.2017.1334002
- Chinn, S., Hart, P. S., and Soroka, S. (2020). Politicization and polarization in climate change news content, 1985–2017. *Sci. Commun.* 42, 112–129. doi: 10.1177/1075547019900290
- Chukwuorji, J. C., Iorfa, S. K., Nzeadibe, T. C., and Ifeagwazi, C. M. (2017). Role of climate change awareness and pro-environmental behaviour in subjective wellbeing. *Niger. J. Soc. Sci.* 13, 39–48.
- Cialdini, R. B., and Kenrick, D. T. (1976). Altruism as hedonism: a social development perspective on the relationship of negative mood state and helping. *J. Pers. Soc. Psychol.* 34, 907–914. doi: 10.1037/0022-3514.34.5.907
- Clayton, S., and Karaszia, B. T. (2020). Development and validation of a measure of climate change anxiety. *J. Environ. Psychol.* 69:101434. doi: 10.1016/j.jenvp.2020.101434
- Cohen, S., and Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. *Psychol. Bull.* 98, 310–357. doi: 10.1037/0033-2909.98.2.310
- Covidence (2022). *Covidence systematic review software*. Veritas Health Innovation, Melbourne. Available at: www.covidence.org.
- Coventry, P. A., Neale, C., Dyke, A., Pateman, R., and Cinderby, S. (2019). The mental health benefits of purposeful activities in public green spaces in urban and semi-urban neighbourhoods: a mixed-methods pilot and proof of concept study. *Int. J. Environ. Res. Public Health* 16:2712. doi: 10.3390/ijerph16152712
- Craft, L. L. (2005). Exercise and clinical depression: examining two psychological mechanisms. *Psychol. Sport Exerc.* 6, 151–171. doi: 10.1016/j.psychsport.2003.11.003
- Elliott, J., Gale, C. R., Parsons, S., and Kuh, D. HALCYON Study Team (2014). Neighbourhood cohesion and mental wellbeing among older adults: a mixed-methods approach. *Soc. Sci. Med.* 107, 44–51. doi: 10.1016/j.socscimed.2014.02.027
- Esmene, S., Leyshon, C., and Leyshon, M. (2020). Beyond adherence to social prescriptions: how places, social acquaintances and stories help walking group members to thrive. *Health Place* 64:102394. doi: 10.1016/j.healthplace.2020.102394
- Feinstein, L., and Hammond, C. (2004). The contribution of adult learning to health and social capital. *Oxf. Rev. Educ.* 30, 199–221. doi: 10.1080/0305498042000215520
- Finnegan, A. (2016). The biopsychosocial benefits and shortfalls for armed forces veterans engaged in archaeological activities. *Nurse Educ. Today* 47, 15–22. doi: 10.1016/j.nedt.2016.03.009
- Fixsen, A., and Barrett, S. (2022). Challenges and approaches to green social prescribing during and in the aftermath of COVID-19: a qualitative study. *Front. Psychol.* 13:861107. doi: 10.3389/fpsyg.2022.861107
- Fraser, J., Clayton, S., Sickler, J., and Taylor, A. (2009). Belonging at the zoo: retired volunteers, conservation activism and collective identity. *Ageing Soc.* 29, 351–368. doi: 10.1017/S0144686X08007915
- Gagliardi, C., Pillemer, K., Gambella, E., Piccinini, F., and Fabbietti, P. (2020). Benefits for older people engaged in environmental volunteering and socializing activities in city parks: preliminary results of a program in Italy. *Int. J. Environ. Res. Public Health* 17:3772. doi: 10.3390/ijerph17113772
- Gordon, J. A., and Borja, S. E. (2020). The COVID-19 pandemic: setting the mental health research agenda. *Biol. Psychiatry* 88, 130–131. doi: 10.1016/j.biopsych.2020.05.012
- Gooch, M. (2005). Voices of the volunteers: an exploration of the experiences of catchment volunteers in coastal Queensland, Australia. *Local Environ.* 10, 5–19. doi: 10.1080/1354983042000309289
- Groarke, J. M., Berry, E., Graham-Wisener, L., McKenna-Plumley, P. E., McGlinchey, E., and Armour, C. (2020). Loneliness in the UK during the COVID-19 pandemic: cross-sectional results from the COVID-19 psychological wellbeing study. *PLoS One* 15:e0239698. doi: 10.1371/journal.pone.0239698
- Hanson, S., and Jones, A. (2015). Is there evidence that walking groups have health benefits? A systematic review and meta-analysis. *Br. J. Sports Med.* 49, 710–715. doi: 10.1136/bjsports-2014-094157
- Hartmann, P., Eisend, M., Apaolaza, V., and D'Souza, C. (2017). Warm glow vs. altruistic values: how important is intrinsic emotional reward in proenvironmental behavior? *J. Environ. Psychol.* 52, 43–55. doi: 10.1016/j.jenvp.2017.05.006
- Hickman, C. (2020). We need to (find a way to) talk about... eco-anxiety. *J. Soc. Work. Pract.* 34, 411–424. doi: 10.1080/02650533.2020.1844166
- Higgins, J. P., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., et al. (2019). *Cochrane handbook for systematic reviews of interventions*. (Chichester, UK: John Wiley & Sons).
- Hoffman, P. (1997). "The endorphin hypothesis" in *Physical activity and mental health*. ed. W. P. Morgan (Washington, DC: Taylor & Francis), 163–178.
- Hoffman, A. J. (2020). Going "green" from gray: providing opportunities of community development and sustainability within a correctional facilities program. *J. Prevent. Intervent. the Commun.* 48, 272–280. doi: 10.1080/10852352.2019.1625605
- Hong, Q. N. (2018). *Revision of the Mixed Methods Appraisal Tool (MMAT): a mixed methods study* [Unpublished doctoral dissertation]. Department of Family Medicine, McGill University, Montréal.
- Hsiao, H.-Y., Hsu, C.-T., Chen, L., Wu, J., Chang, P.-S., Lin, C.-L., et al. (2020). Environmental volunteerism for social good: a longitudinal study of older adults' health. *Res. Soc. Work. Pract.* 30, 233–245. doi: 10.1177/1049731519892620
- Hui, B. P. (2022). Prosocial behavior and well-being: shifting from the 'chicken and egg' to positive feedback loop. *Curr. Opin. Psychol.* 44, 231–236. doi: 10.1016/j.copsyc.2021.09.017
- Hui, B. P., Ng, J. C., Berzaghi, E., Cunningham-Amos, L. A., and Kogan, A. (2020). Rewards of kindness? A meta-analysis of the link between prosociality and well-being. *Psychol. Bull.* 146, 1084–1116. doi: 10.1037/bul0000298

- Hunter, K. E., Webster, A. C., Page, M. J., Willson, M., McDonald, S., Berber, S., et al. (2022). Searching clinical trials registers: guide for systematic reviewers. *BMJ* 377:e068791. doi: 10.1136/bmj-2021-068791
- Husk, K., Lovell, R., Cooper, C., Stahl-Timmins, W., and Garside, R. (2016). Participation in environmental enhancement and conservation activities for health and wellbeing in adults: a review of quantitative and qualitative evidence. *Cochrane Database Syst. Rev.* 2016:CD010351. doi: 10.1002/14651858.CD010351.pub2
- Institute for Health Metrics and Evaluation. (2017). *Global burden of disease collaborative network. Global burden of disease study 2016 (GBD 2016) results*. Available at: www.healthdata.org/sites/default/files/files/policy_report/2019/GBD_2017_Booklet.pdf
- Intergovernmental Panel on Climate Change (2021). *Climate change 2021: the physical science basis contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change*. (Cambridge, UK: Cambridge University Press).
- Isaksson, M., Ghaderi, A., Wolf-Arehult, M., Öster, C., and Ramklint, M. (2021). Sharing and connecting with others patient experiences of radically open dialectical behavior therapy for anorexia nervosa and overcontrol: a qualitative study. *J. Eat. Disord.* 9, 1–10. doi: 10.1186/s40337-021-00382-z
- Joye, Y., and De Block, A. (2011). 'Nature and i are two': a critical examination of the biophilia hypothesis. *Environ. Values* 20, 189–215. doi: 10.3197/096327111X12997574391724
- Kaplan, R., and Kaplan, S. (1989). *The experience of nature: a psychological perspective*. Cambridge, UK: Cambridge University Press.
- Kjellstrom, T., Freyberg, C., Lemke, B., Otto, M., and Briggs, D. (2018). Estimating population heat exposure and impacts on working people in conjunction with climate change. *Int. J. Biometeorol.* 62, 291–306. doi: 10.1007/s00484-017-1407-0
- Klussman, K., Nichols, A. L., Langer, J., and Curtin, N. (2020). Connection and disconnection as predictors of mental health and wellbeing. *Int. J. Wellbeing* 10, 89–100. doi: 10.5502/ijw.v10i2.855
- Kogstad, R. E., Agdal, R., and Hopfenbeck, M. S. (2014). Narratives of natural recovery: youth experience of social inclusion through green care. *Int. J. Environ. Res. Public Health* 11, 6052–6068. doi: 10.3390/ijerph110606052
- Koss, R. S. (2010). Volunteer health and emotional wellbeing in marine protected areas. *Ocean Coast. Manag.* 53, 447–453. doi: 10.1016/j.ocecoaman.2010.06.002
- Landerman, R., George, L. K., Campbell, R. T., and Blazer, D. G. (1989). Alternative models of the stress buffering hypothesis. *Am. J. Community Psychol.* 17, 625–642. doi: 10.1007/BF00922639
- Lawrance, D. E., Thompson, R., Fontana, G., and Jennings, D. N. (2021). *The impact of climate change on mental health and emotional wellbeing: current evidence and implications for policy and practice*. Grantham Institute Briefing Paper No. 36. Available at: https://www.klimareporter.de/images/dokumente/2021/06/The_impact_of_climate_change_on_mental_health_and_emotional_wellbeing_current_evidence_and_implications_for_policy_and_practice_1.pdf
- Lawton, G. (2019). I have eco-anxiety but that's normal. *New Sci.* 244:22. doi: 10.1016/S0262-4079(19)31914-1
- Leavell, M. A., Leiferman, J. A., Gascon, M., Braddick, F., Gonzalez, J. C., and Litt, J. S. (2019). Nature-based social prescribing in urban settings to improve social connectedness and mental well-being: a review. *Curr. Environ. Health Rep.* 6, 297–308. doi: 10.1007/s40572-019-00251-7
- Marselle, M. R., Irvine, K. N., and Warber, S. L. (2013). Walking for well-being: are group walks in certain types of natural environments better for well-being than group walks in urban environments? *Int. J. Environ. Res. Public Health* 10, 5603–5628. doi: 10.3390/ijerph10115603
- Martin, L., White, M. P., Hunt, A., Richardson, M., Pahl, S., and Burt, J. (2020). Nature contact, nature connectedness and associations with health, wellbeing, and pro-environmental behaviours. *J. Environ. Psychol.* 68:101389. doi: 10.1016/j.jenvp.2020.101389
- McManus, S., Meltzer, H., Brugha, T. S., Bebbington, P. E., and Jenkins, R. (Eds.) (2009). Adult psychiatric morbidity in England, 2007: Results of a household survey. *NHS Information Centre for Health and Social Care*. Available at: <https://files.digital.nhs.uk/publicationimport/pub02xxx/pub02931/adul-psyc-morb-res-hou-sur-eng-2007-rep.pdf>
- McManus, S., Bebbington, P. E., Jenkins, R., and Brugha, T. (Eds.) (2016). Mental health and wellbeing in England: The adult psychiatric morbidity survey 2014. *NHS Digital*. Available at: http://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/556596/apms-2014-full-rpt.pdf
- Molsher, R., and Townsend, M. (2016). Improving wellbeing and environmental stewardship through volunteering in nature. *EcoHealth* 13, 151–155. doi: 10.1007/s10393-015-1089-1
- Moore, M., Townsend, M., and Oldroyd, J. (2006). Linking human and ecosystem health: the benefits of community involvement in conservation groups. *EcoHealth* 3, 255–261. doi: 10.1007/s10393-006-0070-4
- Nairn, K. (2019). Learning from young people engaged in climate activism: the potential of collectivizing despair and hope. *Young* 27, 435–450. doi: 10.1177/1103308818817603
- NHS England (2021). *Mental health*. Available at: <https://www.england.nhs.uk/mental-health/>
- O'Brien, L., Townsend, M., and Ebdon, M. (2010). 'Doing something positive': volunteers' experiences of the well-being benefits derived from practical conservation activities in nature. *Voluntas: International Journal of Voluntary and Nonprofit Organizations*, 21, 525–545. doi: 10.1007/s11266-010-9149-1
- O'Brien, L., Burls, A., Townsend, M., and Ebdon, M. (2011). Volunteering in nature as a way of enabling people to reintegrate into society. *Perspect. Public Health* 131, 71–81. doi: 10.1177/1757913910384048
- Orians, G. H., and Heerwagen, J. H. (1992). "Evolved responses to landscapes" in *The adapted mind: evolutionary psychology and the generation of culture*. eds. J. H. Barkow, L. Cosmides and J. Tooby (Oxford, UK: Oxford University Press), 555–580.
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 372:n71. doi: 10.1136/bmj.n71
- Pálsdóttir, A. M., Grahn, P., and Persson, D. (2014). Changes in experienced value of everyday occupations after nature-based vocational rehabilitation. *Scand. J. Occup. Ther.* 21, 58–68. doi: 10.3109/11038128.2013.832794
- Penner, L. A., Dovidio, J. F., Piliavin, J. A., and Schroeder, D. A. (2005). Prosocial behavior: multilevel perspectives. *Annu. Rev. Psychol.* 56, 365–392. doi: 10.1146/annurev.psych.56.091103.070141
- Perkins, D. D., and Zimmerman, M. A. (1995). Empowerment theory, research, and application. *Am. J. Community Psychol.* 23, 569–579. doi: 10.1007/BF02506982
- Pihkala, P. (2020). Anxiety and the ecological crisis: an analysis of eco-anxiety and climate anxiety. *Sustain. For.* 12:7836. doi: 10.3390/su12197836
- Pillemer, K., Fuller-Rowell, T. E., Reid, M. C. A., and Wells, N. M. (2010). Environmental volunteering and health outcomes over a 20-year period. *The Gerontologist* 50, 594–602. doi: 10.1093/geront/gnq007
- Pluye, P., Gagnon, M. P., Griffiths, F., and Johnson-Lafleur, J. (2009). A scoring system for appraising mixed methods research, and concomitantly appraising qualitative, quantitative and mixed methods primary studies in mixed studies reviews. *Int. J. Nurs. Stud.* 46, 529–546. doi: 10.1016/j.ijnurstu.2009.01.009
- Power, A., and Smyth, K. (2016). Heritage, health, and place: the legacies of local community-based heritage conservation on social wellbeing. *Health Place* 39, 160–167. doi: 10.1016/j.healthplace.2016.04.005
- Puhakka, R., Rantala, O., Roslund, M. I., Rajaniemi, J., Laitinen, O. H., and Sinkkonen, A. (2019). Greening of daycare yards with biodiverse materials affords well-being, play and environmental relationships. *Int. J. Environ. Res. Public Health* 16:2948. doi: 10.3390/ijerph16162948
- Reynolds, V. (2000). The green gym. *Volunt. Act. Lond.* 2, 15–26.
- Richardson, M., Passmore, H.-A., Lumber, R., Thomas, R., and Hunt, A. (2021). Moments, not minutes: the nature-wellbeing relationship. *Int. J. Wellbeing* 11, 8–33. doi: 10.5502/ijw.v11i1.1267
- Richardson, M., Cormack, A., McRobert, L., and Underhill, R. (2016). 30 days wild: development and evaluation of a large-scale nature engagement campaign to improve well-being. *PLoS One* 11:e0149777. doi: 10.1371/journal.pone.0149777
- Richardson, M., McEwan, K., and Garip, G. (2018). 30 days wild: who benefits most? *J. Public Ment. Health* 17, 95–104. doi: 10.1108/JPMH-02-2018-0018
- Robinson, J. M., and Breed, M. F. (2019). Green prescriptions and their co-benefits: integrative strategies for public and environmental health. *Challenges* 10:9. doi: 10.3390/challe10010009
- Romeu, D. (2021). Is climate change a mental health crisis? *BJPsych Bull.* 45, 243–245. doi: 10.1192/bjb.2021.30
- Rook, K. S. (1990). Parallels in the study of social support and social strain. *J. Soc. Clin. Psychol.* 9, 118–132. doi: 10.1521/jscp.1990.9.1.118
- Sadler, K., Vizard, T., Ford, T., Marchesell, F., Pearce, N., Mandalia, D., et al. (2018). *Mental health of children and young people in England, 2017*. Leeds, UK: NHS Digital.
- Sarason, S. B. (1974). *The psychological sense of community: prospects for a community psychology*. (San Francisco: Jossey-Bass).
- Schwartz, C. E., and Sendor, M. (1999). Helping others helps oneself: response shift effects in peer support. *Soc. Sci. Med.* 48, 1563–1575. doi: 10.1016/S0277-9536(99)00049-0
- Sobko, T., Liang, S., Cheng, W. H., and Tun, H. M. (2020). Impact of outdoor nature-related activities on gut microbiota, fecal serotonin, and perceived stress in preschool children: the Play&Grow randomized controlled trial. *Sci. Rep.* 10, 1–12. doi: 10.1038/s41598-020-78642-2
- Stanley, S. K., Hogg, T. L., Leviston, Z., and Walker, I. (2021). From anger to action: Differential impacts of eco-anxiety, eco-depression, and eco-anger on climate action and wellbeing. *The Journal of Climate Change and Health*, 1:100003.
- Steg, L., and Vlek, C. (2009). Encouraging pro-environmental behaviour: an integrative review and research agenda. *J. Environ. Psychol.* 29, 309–317. doi: 10.1016/j.jenvp.2008.10.004
- Taufik, D., Bolderdijk, J. W., and Steg, L. (2015). Acting green elicits a literal warm glow. *Nat. Clim. Chang.* 5, 37–40. doi: 10.1038/nclimate2449
- Takase, Y., Hadi, A. A., and Furuya, K. (2019). The relationship between volunteer motivations and variation in frequency of participation in conservation activities. *Environ. Manag.* 63, 32–45. doi: 10.1007/s00267-018-1106-6

- Tashiro, A. (2022). Assessing green management in health belief model: an analysis of a post-disaster rural context. *J. Environ. Manag.* 302:114025. doi: 10.1016/j.jenvman.2021.114025
- Tharrey, M., Sachs, A., Perignon, M., Simon, C., Mejean, C., Litt, J., et al. (2020). Improving lifestyles sustainability through community gardening: results and lessons learnt from the JArDinS quasi-experimental study. *BMC Public Health* 20, 1–13. doi: 10.1186/s12889-020-09836-6
- Townsend, M. (2006). Feel blue? Touch green! Participation in forest/woodland management as a treatment for depression. *Urban Forestr. Urban Green.* 5, 111–120. doi: 10.1016/j.ufug.2006.02.001
- Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., et al. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann. Intern. Med.* 169, 467–473. doi: 10.7326/M18-0850
- Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., and Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *J. Environ. Psychol.* 11, 201–230. doi: 10.1016/S0272-4944(05)80184-7
- Wainberg, M. L., Scorza, P., Shultz, J. M., Helpman, L., Mootz, J. J., Johnson, K. A., et al. (2017). Challenges and opportunities in global mental health: a research-to-practice perspective. *Curr. Psychiatry Rep.* 19, 1–10. doi: 10.1007/s11920-017-0780-z
- Wilson, E. O. (1984). *Biophilia*. (Cambridge, Massachusetts: Harvard University Press).
- Welsh Government (2016). *Welsh health survey*. Available at: <https://gov.wales/sites/default/files/statistics-and-research/2019-02/160622-welsh-health-survey-2015-health-status-illnesses-other-conditions-en.pdf>.
- Weston, P., Hong, R., Kaboré, C., and Kull, C. A. (2015). Farmer-managed natural regeneration enhances rural livelihoods in dryland West Africa. *Environ. Manag.* 55, 1402–1417. doi: 10.1007/s00267-015-0469-1
- Wilkie, S., and Michialino, P. (2014). The influence of participative co-production use for urban public-space regeneration on residents' perceptions of life satisfaction and social cohesion. *J. Architect. Plann. Res.* 31, 271–281.
- Wilson, E. O. (1993). "Biophilia and the conservation ethic" in *The biophilia hypothesis*. eds. S. R. Kellert and E. O. Wilson (Washington, D.C.: Island Press), 31–41.
- Wilson, N., Jones, R., Lafferty, K., Knifton, L., Cathrine, K., Fleming, S., et al. (2009). *Branching out: greenspace and conservation on referral*. Edinburgh: Forestry Commission Scotland, Glasgow Centre for Population Health, Glasgow Clyde Valley Green Network Partnership.
- Yerrell, P. (2008). *National evaluation of BTCV's green gym*. Available at: <https://www.tcv.org.uk/wp-content/uploads/2012/04/green-gym-evaluation-full.pdf>
- Zheng, H., and Echave, P. (2021). Are recent cohorts getting worse? Trends in US adult physiological status, mental health, and health behaviors across a century of birth cohorts. *Am. J. Epidemiol.* 190, 2242–2255. doi: 10.1093/aje/kwab076
- Zijlema, W. L., Klijs, B., Stolk, R. P., and Rosmalen, J. G. (2015). (Un)healthy in the city: respiratory, cardiometabolic and mental health associated with urbanity. *PLoS One* 10:e0143910. doi: 10.1371/journal.pone.0143910
- Zuckerman, M. (1999). "Diathesis-stress models" in *Vulnerability to psychopathology: a biosocial model*. ed. I. M. Zuckerman (Washington, D.C.: American Psychological Association), 3–23.



OPEN ACCESS

EDITED BY

Christian Andreas Klöckner,
NTNU, Norway

REVIEWED BY

Dimitrios Xenias,
Cardiff University, United Kingdom
Emily Ho,
Northwestern University, United States

*CORRESPONDENCE

Daria Mundt
✉ daria.mundt@uni-kassel.de

RECEIVED 27 February 2024

ACCEPTED 30 May 2024

PUBLISHED 26 June 2024

CITATION

Mundt D, Batzke MCL, Bläsing TM, Gomera Deaño S and Helfers A (2024) Effectiveness and context dependency of social norm interventions: five field experiments on nudging pro-environmental and pro-social behavior.

Front. Psychol. 15:1392296.

doi: 10.3389/fpsyg.2024.1392296

COPYRIGHT

© 2024 Mundt, Batzke, Bläsing, Gomera Deaño and Helfers. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Effectiveness and context dependency of social norm interventions: five field experiments on nudging pro-environmental and pro-social behavior

Daria Mundt^{1*}, Marlene C. L. Batzke², Thanee M. Bläsing¹, Sandro Gomera Deaño¹ and Anna Helfers¹

¹Institute for Psychology, Faculty of Human Sciences, University of Kassel, Kassel, Germany, ²Center for Environmental Systems Research, University of Kassel, Kassel, Germany

Social norm interventions hold the potential to change people's behavior. Five field experiments ($N = 1,163$) examined the effects of a simple and easily realizable social norm nudge based on the social media format "Be like Bill." The nudge consisted of a stick figure named Toni that communicated descriptive and injunctive norms regarding pro-environmental or pro-social behaviors. Nudge conditions were compared to no-intervention control conditions. Experiment 1 ($N = 179$) focused on paper towel consumption in a women's restroom at a German university. The nudge condition used less paper towels than the control condition, $d = 0.48$. Experiment 2 ($N = 183$) replicated this result ($d = 0.32$) in a more diverse setting of a women's restroom at a German Christmas market. Experiment 3 ($N = 250$) examined differences in the effects of prescriptive (i.e., 'do-norm') versus proscriptive (i.e., 'do not-norm') social norms on paper towel consumption again in a university women's restroom. The effectiveness of both social norm nudge conditions was shown in comparison to the control condition ($d = 0.46$; $d = 0.40$), while the prescriptive and proscriptive social norm manipulations did not differ. Experiment 4 ($N = 206$) applied the nudging approach to the use of plastic lids in a coffee shop, where no effect was found. Finally, Experiment 5 ($N = 345$) focused on the pro-social behavior of mask wearing in a bakery toward the end of the Covid-19 pandemic restrictions in Germany. In the nudge condition, more visitors put on face masks compared to the control group, $d = 0.39$. Limitations and contextual factors regarding the applicability of our social norm nudge are discussed.

KEYWORDS

behavioral change, social norms, field experiment, waste reduction, injunctive norm, descriptive norm, proscriptive norm, prescriptive norm

1 Introduction

Climate change, resource depletion, and many other environmental challenges facing humanity in the 21st century call for behavioral change. Naturally, change has to occur on many levels. Yet, large-scale global change cannot be achieved without change on the individual level, meaning individuals acting more pro-environmentally (van Valkengoed et al., 2022).

Environmental psychology provides a variety of different approaches to achieving individual behavior change (Abrahamse et al., 2005; Varotto and Spagnoli, 2017). Effective, low-cost, and easy to implement are social influence approaches (Abrahamse and Steg, 2013). In particular, social norms have received a great deal of attention in environmental psychology, being effective in motivating people to change their behavior, even when people think they were not affected (Nolan et al., 2008). Presenting people social norm messages can also be considered a nudge: a small change in the decision-making environment without limiting people's free choice (Thaler and Sunstein, 2008). Social norm nudges have been shown to be a reasonable way to facilitate individual behavior change toward pro-environmentalism and to harvest the so-called low-hanging fruits in behavior change (Bao and Lim, 2022).

The present study investigates the effectiveness of an easy-to-employ social norm nudge designed to promote pro-environmental and pro-social behavior in various real-world contexts. The nudge was tested in different versions as well as in different contexts. In doing so, we aimed for developing a social norm nudge that is ready-for-implementation. So far, situational and contextual variables have gained little attention in the nudging literature (e.g., Czajkowski et al., 2019; Grilli and Curtis, 2021; Mertens et al., 2022; Dannenberg and Weingärtner, 2023). In the present work, one specific nudge was developed and tested in different situational contexts. This allows considering the situational and contextual variables of its effectiveness. The desired outcome of the conducted studies was therefore not only a ready-to-use nudge, but also to provide practitioners with information about when and where it is effective and when not. In doing so, our study also provides valuable insights into empowering citizens to change their practices through practical and scalable behavioral science interventions.

1.1 Social norms and pro-environmental behavior

The power of social norms on behavioral decisions has been shown by a vast body of research and on a wide variety of behaviors, including pro-environmental behaviors such as recycling (e.g., White et al., 2009), energy conservation (e.g., Schultz et al., 2008), and littering (e.g., Keizer et al., 2008), to only name a few (for a review see Dannenberg et al., 2024). Social norms are informal behavioral rules governing everyday life, indicating what other people do or believe is “the right thing” to do. They are most commonly differentiated into descriptive and injunctive norms (Cialdini et al., 1990). A descriptive norm describes what is perceived as “normal” in an empirical sense, meaning the behaviors that other people show in a specific situation (Cialdini et al., 1990, p. 1015). An injunctive norm communicates what is considered as appropriate or inappropriate in a normative sense by other people in a specific situation. They communicate what it is that “ought” to be done (Cialdini et al., 1990, p. 1015). There is research on both types of social norms as well as research showing their individual effects on pro-environmental behavior (Smith et al., 2012). Following this, several studies showed that the combination of both descriptive and injunctive norms had the strongest behavioral effects (Nolan et al., 2008). More specifically, Lee et al. (2007) showed that the combined effect of descriptive and injunctive norms is not only additive but both norms positively interact with each other,

leading to an additional benefit of combining both types of social norms. Combining both types of norms has been shown to have another positive effect. The individual presentation of descriptive norms can lead to so-called boomerang effects, meaning that individuals outperforming the communicated descriptive norm may lower their efforts to match the norm (Schultz et al., 2007, 2008). The boomerang effect disappears when combining the descriptive with an injunctive norm message. Due to the presented advantages of combining descriptive and injunctive norms, that is what we did in the present study.

Another differentiation regarding social norms is the one between prescriptive and proscriptive norms (e.g., Bergquist and Nilsson, 2016; Pavey et al., 2018). A prescriptive social norm describes what is (to be) done and is therefore also referred to as the “do-norm” (cf. Janoff-Bulman et al., 2009; Bergquist and Nilsson, 2019). A proscriptive norm refers to what is *not* (to be) done and is therefore also called a “do not-norm.” Compared to descriptive and injunctive norms, much less is known about their different effects. While it has been shown that proscriptive norm messages lead to higher reactance levels in recipients (Pavey et al., 2021) and suggested that prescriptive norms are more abstract and therefore less effective (Janoff-Bulman et al., 2009), the studies that have tested their independent effects provide an inconclusive picture. Some showed that prescriptive norms are more effective (Bergquist and Nilsson, 2016, study 2; Pavey et al., 2021, study 2; Pavey et al., 2023, study 1), while a slight majority show that proscriptive norms are more effective (Bergquist and Nilsson, 2019, study 3; Cialdini et al., 2006; Mollen et al., 2021, study 2; Pavey et al., 2018, 2021, study 4). As the differentiation between prescriptive and proscriptive norms poses a relevant question for the practical application of norm interventions, namely how to formulate an effective norm message, it was addressed in the present work.

1.2 Nudging as intervention method

A simple intervention method to confront consumers with specific social norms is nudging. Nudging is an overarching term for simple interventions that aim at encouraging desirable behaviors by making small changes in the decision-making environment (e.g., Thaler and Sunstein, 2008; Moseley and Stoker, 2013; Lehner et al., 2016; Schubert, 2017). Among the various nudging techniques, social norm nudges are widely recognized as particularly powerful strategies (Lee et al., 2007; Sunstein, 2014; Byerly et al., 2018). In the pro-environmental setting, nudging interventions were employed for promoting waste reduction and recycling, energy and water conservation, sustainable consumption, and travel (Wee et al., 2021).

Nudging as an intervention method to guide consumers to achieve common goods has gained popularity for several reasons. Firstly, it guides individuals toward desired choices without restricting their freedom (Thaler and Sunstein, 2008). Thus, in contrast to legal restrictions or bans, individuals are still free in choosing between different behavioral options. Secondly, nudging is often cost-effective and easy to implement compared to more traditional policy interventions (Benartzi et al., 2017).

While numerous studies substantiate and underscore the success of nudging, there is also literature casting doubt on its overall efficacy (Maier et al., 2022), along with discussions on the circumstances under which nudging proves effectiveness (e.g., Costa-Font et al.,

2014; Lehner et al., 2016; Szasz et al., 2018). A central finding from this critical discourse concerns the limited generalizability of the individual nudge intervention, since the success of a nudge intervention depends on situational and contextual factors (e.g., Czajkowski et al., 2019; Grilli and Curtis, 2021; Mertens et al., 2022; Dannenberg and Weingärtner, 2023).

Acknowledging the limited generalizability of individual nudging interventions (e.g., Costa-Font et al., 2014; Lehner et al., 2016), our study aims at identifying the boundary conditions of the applicability of our specific social norm nudge to refine the conditions necessary for successful implementation. Since nudging remains a popular choice for policymakers and practitioners (Benartzi et al., 2017), empirical evidence is needed that guides practitioners in tailoring nudges to specific contexts and optimizing their effectiveness. With five field experiments, we offer practical insights for the design and implementation of a scalable social norm intervention.

1.3 The present study

With five field experiments, we investigated the effect of a humorous social norm nudge based on the social media meme “Be like Bill” (Croitoru and Nath, 2016) in three different areas of application (i.e., paper towels usage, lid use of disposable coffee cups and mask wearing). The nudge included an injunctive social norm message with a descriptive social norm.

The goal of the present study was to investigate a simple and ready-to-use intervention that can be easily integrated into existing systems to promote positive behaviors for the environment and society. Particularly in contexts where certain behaviors cannot be prohibited or avoided altogether, cost-effective interventions such as our social norm nudge are useful tools to at least reduce the negative consequences of specific behaviors. Through the implementation of five field experiments, our objective was to comprehensively investigate the specific contexts in which this behavioral nudge is effective. Field experiments are particularly important in this application field, as the results of laboratory experiments cannot always be seamlessly transferred to real-life decision-making scenarios or their effects may be comparatively weakened. Consequently, the knowledge gained from field experiments proves to be helpful for the formulation of practical recommendations (cf. DellaVigna and Linos, 2022). Further, by examining samples that differ in their demographic characteristics, we gain knowledge about potential target groups of this intervention method, since people respond differently to social norms (e.g., Czajkowski et al., 2019; Dannenberg and Weingärtner, 2023).

The first part of this study focused on reducing paper towel usage in public restrooms. With the significance of hand hygiene during and after the Covid-19 pandemic, the prospect of completely eliminating paper towels for environmental reasons appears unlikely, prompting our interest in finding simple ways to reduce individual paper towel consumption. Experiment 1 tested our social norm nudge in a female’s restroom of a university’s learning center. Experiment 2 replicated the same study design in a more heterogeneous setting, a restroom at a Christmas market. Experiment 3 investigated possible differences of the nudge when changing the social norms, i.e., proscriptive versus prescriptive norms. Experiments 4 and 5 extended our nudging paradigm to different application areas, i.e., lids of disposable coffee

cups at a coffee shop with the aim of plastic waste reduction (Experiment 4) and mask wearing during the Covid-19-Pandemic as an example for pro-social behavior (Experiment 5). Table 1 summarizes the main characteristics and results of the five experiments.

2 Experiment 1

Experiment 1 examined our social norm nudge in a female’s restroom of a university’s learning center. The focus on paper towel use in public restrooms as application area for our intervention stemmed from the fact that despite being acknowledged as environmentally unfriendly (Umweltbundesamt, 1993), paper towels are widely regarded as the most hygienic option to dry hands (Hanna et al., 1996; Huang et al., 2012; Best et al., 2014). Considering the heightened importance of hand hygiene during and after the Covid-19 pandemic, eliminating paper towels in favor of the environment seems unlikely. Consequently, our interest lay in finding a simple yet effective way to reduce individuals’ paper towel consumption.

Effective nudge interventions were already found in the context of hand hygiene. For example, hand washing frequencies could be increased by showing arrows leading to sinks (Blackwell et al., 2017). A normative sign was useful to increase the use of sanitizer (Aarestrup et al., 2016). Goldstein et al. (2008) discovered that incorporating descriptive norm messages, informing guests about the prevalence of towel reuse, resulted in a higher rate of towel re-usage in hotel rooms. Concerning paper towel use, Lee et al. (2020) failed to produce a nudging-effect with their descriptive social norm nudge, including a detailed description of how to dry one’s hands with one paper towel only. Reactance of the participants was suggested as a possible explanation (cf. reactance theory by Brehm, 1966). With our humorous social norm nudge, we tried to counteract any emerging reactance through the intervention. Since previous research found the combination of descriptive and injunctive social norms to be successful in nudging people’s behavior (Schultz et al., 2007), we expected participants who were nudged by our social norm nudge to use less paper towels than participants in a control group without any nudge intervention.

2.1 Method

The study was preregistered before data collection at: <https://osf.io/s2bqz>.

2.1.1 Design and sample

Our field experiment followed a one-factorial between-subjects design with the independent variable nudge (control condition vs. nudge condition) and the dependent variable amount of used paper towels.

Participants were $N = 179$ female-presenting adults (estimated age range¹: 18 to 32 years, $M = 23.08$, $SD = 2.39$), with 89 participants in the nudge condition and 90 participants in the control condition. Our data collection included all individuals who washed their hands

¹ We would like to point out that our age estimates in all five experiments were based solely on the personal perceptions of our experimenters and not on any specific or standardized procedure.

TABLE 1 Summary of experiments 1–5.

Exp.	Setting	N	Type of sample	Dependent variable	Independent variable	Statistical significance	Effect size
1	Restroom (university)	179	female students	used paper towels	social norm vs. control	$p < 0.001$	$d = 0.48$
2	Restroom (christmas market)	183	female adults	used paper towels	social norm vs. control	$p = 0.015$	$d = 0.32$
3	Restroom (university)	250	female students	used paper towels	prescriptive norm vs. control	$p = 0.002$	$d = 0.46$
					proscriptive norm vs. control	$p = 0.005$	$d = 0.40$
					prescriptive vs. proscriptive	$p = 0.777$	$d = 0.04$
4	Coffee shop	206	adults (male and female)	used plastic lids	social norm vs. control	$p = 0.881$	$d = 0.02$
5	Bakery	345	adults (male and female)	mask wearing	social norm vs. control	$p = 0.006$	$d = 0.39$



in the restroom, while excluding those who made multiple restroom visits during the observation period (based on experimenters' recognition), participants who witnessed the nudge installation, individuals who used paper towels for purposes other than hand drying, and cases where the count of taken paper towels was ambiguous. Participants did not know that they were part of an experiment.

An *a priori* sample size estimation with G*Power (version 3.1.9.6, [Faul et al., 2007](#)) suggested an optimal sample size of 176 participants for a one-tailed independent *t*-test. We assumed a Type-1 error probability of 0.05, a power of 0.95 and a medium-sized effect of $d = 0.50$.

2.1.2 Material

The intervention was a self-designed nudge. Its design was based on the social media format “Be like Bill” ([Croitoru and Nath, 2016](#)), but given the gender-neutral name “Toni.” It was printed in color on paper (13.5 cm x 13.5 cm; 100 g/m²) and laminated in. At the left hand-side of the stick figure was the following text written: “This is Toni. Toni is cool and environmentally conscious. Toni only takes 1 paper towel. Be like Toni. Take 1 tissue only.” (close English translation). The message combines an injunctive norm (“Toni is cool and environmentally conscious.”) and a descriptive norm message (“Toni only takes 1 paper towel.”). The stick figure holds a paper towel in its left hand. The right hand was showing a thumb sticking up. A small sun and flowers were meant to reinforce an environmental association (see [Figure 1](#)).

2.1.3 Procedure

The field experiment took place in May 2022 in the women's restroom located in a learning center at a German University. The restroom consisted of a sink with a large mirror above it, two paper towel dispensers on the left and right, and a trash can positioned to the right of the sink. Additionally, there were three toilet cubicles situated in a separate room, accessible through a door.

In the nudge condition, the nudge-stickers were placed in the center of both paper towel dispensers. In the control condition, the nudge-stickers were taken off. We rotated the condition approximately every 15 people to ensure randomized assignment to conditions and avoid day and time effects. The exact number of people before changing the condition was adjusted if people were still in the restroom at the time of a scheduled condition change. To count the used paper towels for each participant, a female experimenter remained inconspicuously in the restroom. In order not to attract attention, she carried out inconspicuous activities such as braiding hair, cleaning glasses, filling bottles or checking cell phones - behaviors that are frequently observed in women's toilets and are therefore not considered unusual for the test subjects. An observation period lasted

45 min each time and was followed by a 15-min break before experimenters changed.

2.2 Results

Data processing and analysis was conducted in R (version 4.3.2; [R Core Team, 2021](#)). As inference criteria, we employed an alpha level of 0.05.

The number of paper towels used ranged from 0 to 9 towels. To test our hypothesis, we ran a one-tailed Welch t-test between two independent means. Participants in the nudge condition used less paper towels ($M=2.45$, $SD=1.33$) than the control condition ($M=3.11$, $SD=1.42$), $t(176.53)=3.22$, $p<0.001$, $d=0.48$, confirming our hypothesis.

2.3 Discussion

Experiment 1 found participants to use less paper towels when shown our humorous social norm nudge combining descriptive and injunctive social norms compared to participants who were not confronted with any nudge intervention.

In this first experiment, our sample consisted of young, female-presenting academic students. Young adults are often more sustainability-oriented than groups of older people ([Yamane and Kaneko, 2021](#)). Therefore, they might be more responsive to our social norm nudge. Moreover, due to their activities in social media, young adults might also be more familiar with the “Be Like Bill”-format than older adults. It is possible that the effect of the nudge also depends on its popularity and therefore, is less effective in older adults. Therefore, in Experiment 2, we tested our nudge with a more heterogeneous sample, not only related to age, but also to other social demographic characteristics, as for instance their educational background. Investigating the nudge also with an educational heterogeneous sample is crucial for further practical recommendations of our used nudge, since our nudge intervention communicates social norms in written format.

3 Experiment 2

To explore the nudge’s effectiveness, Experiment 2 extended the same nudge intervention to a more diverse setting, specifically a female restroom at a Christmas market. As the experiment took place outside the university, at an event of widespread interest to the town’s population, we anticipated a more varied sample compared to Experiment 1 regarding age and educational backgrounds. Since the applicability of nudge intervention depends on situational and contextual constraints ([Czajkowski et al., 2019](#); [Grilli and Curtis, 2021](#); [Mertens et al., 2022](#); [Dannenberg and Weingärtner, 2023](#)), the examination of the nudge’s effectiveness with a different target group is vital for practical recommendations. We kept the area of application (paper towel use in public women’s toilets) and the nudge itself constant in order to be able to make appropriate statements about the scalability of the nudge intervention regarding other demographic characteristics of the target group. As for experiment 1, we expected participants in the nudge condition to use less paper towels than participants in a control condition (directional).

3.1 Method

The study was preregistered before data collection at: <https://osf.io/xmnkh>.

3.1.1 Design and sample

Our field experiment followed a one-factorial between-subjects design with the independent variable nudge (control condition vs. nudge condition) and the dependent variable amount of used paper towels.

Participants were $N=183$ female-presenting adults (estimated age range: 19 to 75 years, $M=42.51$; $SD=14.56$), with 88 participants in the nudge condition and 95 participants in the control condition. Our data collection included all individuals who washed their hands in the restroom, while excluding those who made multiple restroom visits during the observation period (based on experimenters’ recognition), participants who witnessed the nudge installation, individuals who used paper towels for purposes other than hand drying, and cases where the count of taken paper towels was ambiguous. Participants did not know that they were participating in an experiment.

An *a priori* sample size estimation with G*Power (version 3.1.9.6, [Faul et al., 2007](#)) suggested an optimal sample size of 176 participants for a one-tailed independent t-test. We assumed a Type-1 error probability of 0.05, a power of 0.95 and a medium-sized effect of $d=0.50$.

3.1.2 Procedure

The field experiment was conducted in December 2022 in a public restroom on the Christmas market in a mid-sized German city. Two restroom containers were located next to each other, each container contained three toilets and one sink. On the left side of the sink was the paper towel dispenser, directly over the sink was a small mirror. A small trash bin was located under the paper towel dispenser. The door of the restroom container was open, so that the experimenter could unobtrusively observe the sink from outside of the container. The experimenters disguised as waiting relatives - a not uncommon behavior for restroom visits at such events. By doing so, they did not raise attention by staying in the restroom container without a purpose.

In the nudged condition, the same nudge from Experiment 1 was placed on top of the paper towel dispenser, so that the subject had to look at the nudge while pulling paper towels from the dispenser.

3.2 Results

The statistical analysis was executed in R (version 4.3.2; [R Core Team, 2021](#)). As inference criteria, we employed an alpha level of 0.05.

The range of used paper towels was from 0 to 6. To test our hypothesis that less paper towels were used in the nudge condition compared to the experimental condition, we ran a one-tailed Welch t-test between two independent means. Confirming our hypothesis, participants in the nudged condition used less paper towels ($M=2.19$; $SD=0.92$) than people from the control condition ($M=2.54$ $SD=1.19$), $t(175.42)=2.19$, $p=0.015$, $d=0.32$.

3.3 Discussion

Experiment 2 successfully replicated the results of Experiment 1, demonstrating that participants who were exposed to a social norm

nudge used fewer paper towels compared to those who did not receive any nudge intervention. This indicates that our nudging approach was effective not only with a young academic sample but also with a more diverse sample regarding age and educational background. It should, however, be noted that the effect size in Experiment 2 was smaller than in Experiment 1.

4 Experiment 3

Experiment 3 was intended to investigate potential differences in the wording of the nudge with regard to prescriptive or proscriptive norms (see Section 1.1). Prescriptive norms describe a behavior that is normal or appropriate (i.e., “do-norm”) and proscriptive norms refer to behavior that is not normal or inappropriate (i.e., “do not-norm”). So far, there are inconclusive findings concerning their effectiveness in norm interventions, while there is a slight majority of studies supporting the superiority of proscriptive norms (Bergquist and Nilsson, 2019, study 3; Cialdini et al., 2006; Mollen et al., 2021, study 2; Pavey et al., 2018, 2021, study 4). Therefore, testing whether proscriptive norms are more effective than prescriptive norms seems relevant for the present norm nudge as well as for other social norm interventions. Based on the results of Experiments 1 and 2, we generally expected an intervention effect. Thus, compared to participants who were not exposed to any nudge intervention, we expected a lower paper towel use for participants who were exposed to the prescriptive nudge (H1), or respectively, to the proscriptive nudge (H2). Based on the cited literature, we hypothesized that participants who were exposed to a proscriptive nudge consume less paper towels than participants who were exposed to a prescriptive nudge.

4.1 Method

The study was preregistered before data collection at: <https://osf.io/hzcxw/>.

4.1.1 Design and sample

Our field experiment followed a one-factorial between-subjects design with the independent variable nudge (control condition vs. prescriptive social norm nudge vs. proscriptive social norm nudge) and the dependent variable amount of used paper towels.

Participants were $N = 250$ female-presenting adults (estimated age range: 18 to 66 years ($M = 22.18$; $SD = 4.02$)), with 82 participants in the prescriptive norm condition, 82 in the proscriptive norm condition and 86 participants in the control condition. As before, we included everyone in our data collection who washed and dried their hands in the restroom, while excluding those who made multiple bathroom visits during the observation period (based on experimenters' recognition), participants who witnessed the nudge installation, and individuals who used paper towels for purposes other than hand drying. Participants did not know that they were participating in an experiment.

An *a priori* sample size estimation with G*Power (Version 3.1, Faul et al., 2007) suggested an optimal sample size of 258 participants for three one-tailed independent *t*-tests. Due to Bonferroni correction,

we assumed a Type-1 error probability of 0.017, a power of 0.90 and a medium-sized effect of $d = 0.50$.

4.1.2 Material

In our prescriptive and proscriptive nudge condition we used a modified “Be like Toni” meme as it was used in Experiment 1.

Our prescriptive meme showed a smiling stick figure holding a single paper towel in its left hand. Above the head of the stick figure we placed a green thumbs up. On the left of the stick figure a smiling sun and blooming flowers were located to underpin the aspect of environmentally friendly behavior. Additionally, the following text was written: “This is Toni. Toni is cool and environmentally conscious. Toni only takes 1 paper towel. Be like Toni. Take 1 tissue only.” (close English translation). Our proscriptive meme showed a disinterested looking stick figure holding several paper towels in both hands. Above the head of the stick figure we placed a red thumbs down. On the left of the stick figure an unpleasant looking sun and withered flowers were located to underpin the aspect of environmentally harmful behavior. Additionally, the following text was written: “This is Toni. Toni is uncool and harmful to the environment. Toni takes more than one paper towel. Do not be like Toni. Do not take more than one paper towel.” (close English translation).

4.1.3 Procedure

The field experiment was conducted in December 2022, once again in the same female restroom used in Experiment 1, located at a university's learning center.

In the experimental conditions, the prescriptive or proscriptive nudge-stickers were placed in the center of the paper towel dispenser that was located in the restroom right from the mirror and the sink. In the control condition, the nudge stickers were taken-off. We rotated the condition after every observation period, to ensure randomized assignment to conditions and avoid day and time effects. An observation period lasted 45 min each time and was followed by a 15-min break before the experimenter changed. One of the three female experimenters was present in the restroom to record the quantity of paper towels used by each participant. To avoid drawing attention, the experimenters engaged in activities such as refilling a water bottle, applying makeup, cleaning glasses, or using their phones. In order not to attract attention, the experimenter carried out inconspicuous activities such as refilling bottles or checking cell phones, as in experiment 1 - behaviors that are frequently observed in female restrooms and are therefore perceived as normal by the test subjects. However, they refrained from drying their own hands to prevent any potential influence on the participants' behavior.

4.2 Results

Data processing and analysis was conducted in R (version 4.3.2; R Core Team, 2021). To test our three hypotheses, we run three one-tailed Welch *t*-tests between two independent conditions. As inference criteria, we employed an alpha level of 0.017, as we applied a Bonferroni correction to adjust our overall alpha level of 0.05.

The number of paper towels used ranged from 1 to 8 towels. Hypothesis 1 was confirmed, as participants in the prescriptive nudge condition ($M = 2.89$, $SD = 1.31$) used fewer paper towels compared to those in the control condition ($M = 3.50$, $SD = 1.31$), $t(165.54) = -3.01$,

$p=0.002$, $d=0.46$. Also, Hypothesis 2 was supported, as participants in the proscriptive nudge condition ($M=2.95$, $SD=1.44$) used fewer paper towels compared to those in the control condition, $t(162.68)=-2.58$, $p=0.005$, $d=0.40$.

No difference in paper towels usage was found between participants in the proscriptive nudge condition and the prescriptive nudge condition, $t(160.69)=-0.28$, $p=0.777$. Thus, we could not confirm Hypothesis 3 that less paper towels were used in the proscriptive nudge condition compared to the prescriptive nudge condition.

4.3 Discussion

Experiment 3 replicated the results of Experiments 1 and 2, reaffirming the effectiveness of our social norm nudge intervention in female restrooms to reduce paper towel usage. The study demonstrated that the social norm nudge intervention was effective with both prescriptive and proscriptive norm messages. Yet, no significant difference was observed between prescriptive and proscriptive norms. Hence, the assumed stronger effects for proscriptive norms could not be supported and the following experiments (4 and 5) only applied prescriptive norms. The effect size was similar to Experiment 1, thus stronger than in Experiment 2.

5 Experiment 4

To explore the effectiveness of the nudge in different contexts and regarding a different pro-environmental behavior, Experiment 4 examined the impact of our nudge on the usage of plastic lids for disposable cups.

In Germany, approximately 2.8 billion hot beverages consumed in disposable to-go cups result in about 28,000 tons of waste annually. The environmental impact of these to-go cups largely hinges on customers' decision to use or not to use a plastic lid, with opting for no lid being the more environmentally friendly choice (Kauertz et al., 2019). Several studies speak for social norm nudging as an effective approach to reduce single-use plastic lids for hot beverages to-go. For example, Loschelder et al. (2019) demonstrated the efficacy of norm-based nudging in helping café customers avoid disposable to-go cups. Dorigoni and Bonini (2023) successfully reduced the demand for bottled water in favor of tap water for beverages by implementing a written descriptive norm intervention. Therefore, we hypothesized that customers of the experimental group who were exposed to the nudge are less likely to use a plastic lid for their to-go coffee than customers of the control group who were not exposed to the nudge.

5.1 Method

The study was preregistered at: <https://osf.io/3knyv>.

5.1.1 Design and sample

Our field experiment followed a one-factorial between-subjects design with the independent variable nudge (control condition vs. nudge condition) and the dependent variable lid use (0 = no use, 1 = use).

For data collection, we included everyone who bought a beverage in a to-go cup. A total of 208 participants were included in our data set. Participants did not know that they were participating in an experiment. Two customers who were estimated to be 17 years old were excluded from data analysis. Our final sample were $N=206$ adults (99 male-presenting, 106 female-presenting, 1 diverse-presenting; estimated age range: 18 to 67 years, $M=39.62$, $SD=13.67$), with 102 participants in the experimental condition (48 male-presenting, 54 female-presenting) and 104 participants in the control condition (51 male-presenting, 52 female-presenting, 1 diverse-presenting).

An *a priori* sample size estimation with G*Power (version 3.1.9.6, Faul et al., 2007) suggested an optimal sample size of 208 participants for a one-tailed binomial logistic regression (z -test). We assumed a Type-1 error probability of 0.05, a power of 0.95 and an effect size of $OR=0.21$ (based on estimated probabilities for $p(H1)=0.8$ and $p(H0)=0.95$).

5.1.2 Material

Our nudge was similar to the previous experiments, this time depicting a stick figure holding a cup of coffee without plastic lid in its right hand. The text said: 'This is Toni. Toni is environmentally friendly. Toni goes without lid. Be like Toni. Go without lid.' (close English translation). The nudge was printed in color on a 20x20cm surface and protected with lamination.

5.1.3 Procedure

The research took place in December 2022 at a self-service café of a long-distance train station in Germany. Two self-service coffee machines were available, with disposable cups being the default choice. Milk, sugar, and plastic lids were accessible at a separate counter either before or after payment. During the intervention, the nudge sign was placed next to the stack of plastic lids at the self-service counter. To ensure random assignment of participants to the two conditions, the researchers removed or installed the nudge sign after approximately every 10 participants, taking precautions to prevent subsequent participants from noticing the change. If any participants did happen to notice the alteration, they were not included in our data collection. In cases where participants purchased multiple cups of coffee, they were classified as lid-users if they used a lid for at least one of the cups. The experimenters sat at a table with a view of the coffee machine and the cup-lid counter to observe customers' choices, attempting to blend in as regular customers, drinking coffee, chatting and playing on their cell phones.

5.2 Results

Data processing and analysis was conducted in R (version 4.3.2; R Core Team, 2021). As inference criteria, we employed an alpha level of 0.05.

A lid was taken by 47.12% of the participants in the control condition and by 46.08% in the experimental condition.

To analyze the effect of the nudge intervention on the lid choice, a one-tailed binomial logistic regression was conducted with the predictor condition (0 = control, 1 = experimental) and the criterion lid choice (0 = no lid, 1 = lid). The regression model indicated no statistical difference between both nudge conditions, $B=-0.04$

(SE = 0.28), $z = -0.15$, $p = 0.881$. The model fit was not significant, $\chi^2(1) = 0.02$, $p = 0.881$, Nagelkerke's $R^2 = 0.00$.

5.3 Discussion

Experiment 4 examined the effectiveness of our social norm nudge aimed at reducing the usage of plastic lids for to-go cups. We were unable to replicate findings of Experiments 1–3, thus, customers exposed to the nudge were not less likely to use a plastic lid compared to those not exposed to the nudge. There are several reasons why the nudge did not work in this context.

In Experiments 1–3, the nudge was introduced in a relatively calm environment, allowing participants time to adapt their behavior to the nudging situation. However, in Experiment 4 conducted at a train station, individuals were likely to be more hurried and concerned about avoiding spills while holding their beverages. Hence, the nudge intervention may have been unsuccessful due to the essential need for lids in a travel setting, highlighting a potential contextual dependency of our nudge intervention. Further, due to the hurry, inattentive blindness (Mack, 2003; Jensen et al., 2011) might have occurred, where something is not noticed unless attention is consciously directed toward it, despite being right in front of one's eyes. In our case, participants' attention was maybe focused on catching their train or quickly leaving, diverting their attention from the nudge stand. Moreover, the stress experienced by individuals at a train station may also influence decision-making regarding taking a lid or not. Under stress, humans tend to rely on automatic cognitive processes (Alexander et al., 2007; Starcke and Brand, 2012). In our experimental context, this implies that even if participants noticed the nudge, they may not have had the mental capacity at that moment to fully contemplate its message and change their habits. Consequently, it would be interesting to conduct a replication of this study in a café setting where customers have more time available. This would help investigate whether the time factor played a role in hindering customers from adapting their behavior as observed in the previous study.

6 Experiment 5

In Experiment 5, the focus was extended to the context of health messages during the COVID-19 pandemic. Having identified the nudge as an effective behavioral nudge in prior studies, it was now evaluated in its ability to increase voluntary mask wearing.

During the Covid-19 pandemic mask wearing had been identified as one of the most effective behaviors reducing the transmission risk of Covid-19 (e.g., Howard et al., 2021; Zhang and Jin, 2023). A long phase of mandatory mask wearing in Germany ended on 19th March 2022 (COVID-19 Snapshot Monitoring, 2023). As a result, mask wearing rates in Germany strongly dropped (COVID-19 Snapshot Monitoring, 2023) despite health officials still encouraged to wear masks on a voluntary basis (Presseagentur, 2022).

This study sought to increase voluntary mask wearing in a bakery in a heterogeneous sample comprising men and women of different ages during the Covid-19 pandemic. Social norm messaging had been successfully employed in encouraging pandemic health behavior such as hand sanitizer use (Mobekk and Stokke, 2020) and increasing

vaccination rates (Zhang and Jin, 2023). For the specific behavior of mask wearing, a longitudinal study found that social norms were important determinants of mask wearing behavior (with descriptive norms being more influential than injunctive norms) (Heiman et al., 2023).

It was therefore expected that presenting the social norm nudge to customers in a bakery increases their voluntary health behavior of wearing a face mask. If social norm nudges positively influence health behavior, customers in the experimental group who were exposed to the nudge are more likely to wear a face mask when entering the bakery than customers in the control group who were not exposed to the nudge.

6.1 Method

The study was preregistered before data collection at: <https://osf.io/xcnd4>.

6.1.1 Design

Our field experiment had a one-factorial between-subjects design with the independent variable nudge (control condition vs. nudge condition) and the dependent variable amount of mask wearing (yes vs. no).

6.1.2 Sample

Participants were $N = 345$ adults (181 male-presenting, 164 female-presenting; estimated age range: 19 to 85 years, $M = 44.81$; $SD = 14.95$), with 161 participants in the experimental condition (105 male-presenting, 79 female-presenting) and 184 participants in the control condition (76 male-presenting, 85 female-presenting).

An *a priori* sample size estimation with G*Power (version 3.1.9.6, Faul et al., 2007) suggested an optimal sample size of 226 participants for a one-tailed binomial logistic regression (z -test). We assumed a Type-1 error probability of 0.05, a power of 0.95 and an effect size of $OR = 2.67$ (based on estimated probabilities for $p(H1) = 0.40$ and $p(H0) = 0.20$).

We included all participants that have entered the local bakery. All participants who wore a mask more than two meters away from the nudge before entering the bakery, were excluded from both conditions to ensure that they have perceived the nudge. Subjects under the estimated age of 18 were excluded as well. Participants did not know that they were participating in an experiment.

6.1.3 Material

Our nudge was similar to the previous experiments, this time depicting a stick figure wearing a mask. Above the stick figure, we wrote: 'This is Toni. Toni is cool and conscientious toward other people. Toni is wearing a mask. Be like Toni. Wear a mask.' (close English translation). Again, our self-created stick figure puts a thumb up. The nudge was printed on a DIN-A4 note.

6.1.4 Procedure

The field experiment was conducted in December 2022 at a local bakery. The bakery shop was equipped with a counter on the left side at the entrance where the sales assistants could serve their customers. On the right side of the entrance there were seats and tables. The observers sat down on the corner of the bakery shop. To make sure

that they do not attract attention, activities such as chatting or drinking coffee were performed like normal customers. During the observations, they were not wearing a mask except when standing up to attach or remove the social norm nudge. The bakery staff always wore a mask. In the experimental nudge condition, the social norm nudge was attached with scotch tape at the windshield of the bakery shop entry. In the control condition, the social norm nudge was taken off. After every attachment, the observers sat down again and counted which participants were putting their masks on two meters away before entering the bakery. After every 20 participants the conditions were rotated.

6.2 Results

Data processing and analysis was conducted in R (version 4.3.2; [R Core Team, 2021](#)). As inference criteria, we employed an alpha level of 0.05.

A mask was put on by 16.85% of the participants in the control condition and by 26.19% in the experimental condition.

To analyze the effect of the nudge intervention on the mask wearing, a one-tailed binomial logistic regression was conducted with the predictor condition (0 = control, 1 = experimental) and the criterion mask wearing (0 = no mask, 1 = mask). The regression model indicated statistical difference between both nudge conditions, $B = 0.71$ ($SE = 0.26$), $z = 2.71$, $p = 0.007$, $OR = 2.03$, $d = 0.39$. The model fit was significant, $\chi^2(1) = 7.49$, $p = 0.006$, McFadden's pseudo- $R^2 = 0.02$. Thus, the proportion of mask-wearing participants in the nudge condition (29.19%) was significantly higher than in the control condition (16.85%), confirming our hypothesis.

6.3 Discussion

Experiment 5 examined the effectiveness of the Be-like-Toni-nudge in the context of health messages. Our hypothesis that customers exposed to the nudge were more likely to wear a face mask when entering a bakery was supported. Experiment 5 thereby showed that the nudge can be scaled up to different types of behavior and is applicable in heterogeneous contexts. Experiment 5 furthermore proved the nudge to be effective in target groups with mixed gender. The effect size was similar to Experiment 2, thus smaller than for Experiment 1 and 3.

It is worth noting that the nudge used in our study may have interacted with latent variables such as self-protection, health concerns, or social desirability, thereby influencing participants' behavior. While we focused primarily on the observable outcome of mask wearing, future studies should consider the potential interactions between the effectiveness of this nudge intervention and the underlying individual motivation of mask wearing.

7 General discussion

With five field experiments, we investigated the applicability of an easy-to-implement social norm nudge, based on the social-media meme "Be like Bill" ([Croitoru and Nath, 2016](#)), combining descriptive with injunctive social norm messages. While we could replicate a

nudging effect in all three experiments aiming at paper towel reduction (Experiments 1–3) as well as mask wearing (Experiment 5), we could not find a nudging effect concerning plastic lid reduction in a coffee shop at a train station (Experiment 4). The nudge was found to be slightly more effective in homogenous samples (Experiment 1 and Experiment 3) as compared to more heterogeneous samples in terms of age, gender, and educational background (Experiment 2 and Experiment 5).

Acknowledging the limited generalizability of individual nudging interventions (e.g., [Czajkowski et al., 2019](#); [Grilli and Curtis, 2021](#); [Mertens et al., 2022](#); [Dannenberg and Weingärtner, 2023](#)), our study aimed at identifying patterns that enhance the generalizability of our nudge intervention across diverse situations. Our nudge intervention is a very cost-effective intervention which, due to its simplicity, can easily be integrated into existing systems and therefore, implemented by practitioners. Our incremental changes from experiment to experiment allow us to systematically test assumptions about the scalability of our nudge intervention. The following recommendations can guide practitioners in tailoring this simple intervention to specific contexts and optimizing its effectiveness.

7.1 Applicability and boundaries of the presented social norm nudge

7.1.1 Target behaviors and contexts

We observed effects for both paper towels in public toilets and mask wearing during the Covid-19 pandemic. These findings suggest that our nudging intervention is applicable for different target behaviors and thus can serve as a tool to promote pro-environmental and pro-social behaviors. Further replications in different application areas are needed to substantiate this assumption.

The nudge was found ineffective in reducing the consumption rate of plastic lids of disposable coffee cups. This result can be attributed to the contextual conditions rather than to the applicability of the plastic lids *per se*. It can be assumed that the nudge might be effective when the individual is in a decision situation without time pressure and stress. In Experiment 4, the presence of inattention blindness ([Mack, 2003](#); [Jensen et al., 2011](#)) and heightened stress levels during the decision-making process ([Alexander et al., 2007](#); [Starcke and Brand, 2012](#)), exacerbated by the urgency to catch a train, may have caused customers to overlook or ignore our nudge intervention. Furthermore, the fear of possible negative consequences, such as spilled coffee, during the rush to reach the platform might distract attention from the intended effect of the nudge. Therefore, it is plausible that the intervention on plastic lids did not elicit the desired behavioral change, because of the overwhelming influence of situational factors. Consequently, it is imperative to further explore the intervention's impact in diverse settings, given that distinct situational contexts can influence the efficacy of such nudging interventions (e.g., [Costa-Font et al., 2014](#); [Lehner et al., 2016](#); [Czajkowski et al., 2019](#)). Modest adjustments to study designs, as undertaken in this instance, are therefore of great importance in order to determine the scalability of individual interventions.

7.1.2 Sample

Our study examined people of different ages, genders, educational levels and socio-economic backgrounds, whereby the latter two

aspects can be assumed based on the study location (Christmas market and bakery). Since we found intervention effects in more homogenous samples (female university students) as much as for more heterogeneous samples (customers of a city's Christmas market and of a bakery), we assume that our intervention can be applied to a large proportion of the population. Regarding gender effects, it is important to acknowledge that Experiments 1–3 were conducted exclusively in female restrooms (due to constraints in time and personnel resources). The findings from Experiment 5 indicate that the behavioral nudge might be effective in men's toilets as well. However, further investigation focussing especially on gender differences is warranted in future studies to validate this observation. Thus, previous research has shown that some nudge interventions appeal more to women, others more to men (e.g., [Czap et al., 2018](#)). It is therefore necessary to check whether the nudge intervention also works in male restrooms, or whether men show maybe less or no behavioral change due to reactance, for example. It is noteworthy that the effect sizes observed in the more heterogeneous sample compositions (Experiments 2 and 5) were smaller compared to those in Experiments 1 and 3, which employed more homogeneous samples. This observed variation prompts a more in-depth exploration of the effectiveness of our nudge intervention across diverse settings. On the one hand, the diminished effect sizes could be attributed to several factors. First, varied interpretations and acceptance of social norms depending on sociodemographic variables may have contributed to differences in the effectiveness of nudges among participants ([Dannenberg and Weingärtner, 2023](#)). Second, the level of familiarity with the presented meme could influence the effectiveness of the nudge. Third, participants with varying levels of reading proficiency may respond differently to the nudge, affecting its overall effectiveness.

On the other hand, the effectiveness of the nudge may also be influenced by the specific context in which participants were nudged. For example in Experiment 2, the restroom environment at the Christmas Market, characterized by close quarters and colder temperatures, may make the hand-drying experience less comfortable, potentially reducing individuals' inclination to dry their hands with greater attention. In the case of Experiment 5, the limited time to stop and get a mask from the bag, the general habit of wearing masks, and the availability of free hands to put on the mask could play a role in the effectiveness of nudges during a bakery visit.

Considering this, further investigation into the nuanced interplay between individual characteristics and contextual factors is warranted for a more comprehensive understanding of the scalability of our nudge. Regardless of this, the aspects already found highlight the potential impact of our nudge intervention among diverse sample compositions and varying situational contexts.

7.1.3 Nudge message

To counteract possible reactance induced by the nudge intervention (cf. [Lee et al., 2020](#)), we decided to use the humorous social media meme “Be like Bill” ([Croitoru and Nath, 2016](#)) as the basis of our intervention. Because of a possible character identification (cf. [Festinger, 1954](#); [Hoffner, 2020](#)), we decided to give the stick figure the gender-neutral name Toni instead of keeping the previous name Bill. The necessity of this change remains uncertain; however, the nudge proved effective, even if it deviated slightly from the original. It may be worthwhile to further investigate in future

studies whether the choice of name influences the results (at all) and what role the meme's level of recognition plays in the expression of these effects.

As the question concerning the superiority of positively versus negatively worded norm nudges remains somewhat unclear, we compared the effectiveness of prescriptive and proscriptive norm nudges. The difference between the norm messages showed insignificant, similar to some of the existing research ([Leoniak and Maj, 2016](#); [Mollen et al., 2021](#), study 1). One might conclude based on these results that prescriptive and proscriptive norms are similarly effective. Regarding the mixed results that studies showed, it may also well be that there are moderating variables influencing the effectiveness, which yet have to be investigated. For example, majority social norms might be more effectively communicated via proscriptive norms. Research has shown that proscriptive norms arouse more reactance ([Bergquist and Nilsson, 2016](#)) and are linguistically less abstract and therefore potentially more effective ([Janoff-Bulman et al., 2009](#)). Therefore, one might assume that in communicating social norms that the majority of people share, proscriptive norms are more effective as reactance is less prevalent in general. For the same reasons, it could be better to communicate minority social norms via prescriptive norms. This remains to be tested.

7.1.4 Temporal effectiveness

Our study focused on short-term interaction effects only, thus how the presentation of our social norm nudge affects an immediate behavioral decision. Therefore, our results do not allow any conclusions regarding the long-term effect of this intervention method. Generally, the state of research concerning the long-term effect of nudging is expandable ([Venema et al., 2018](#)). [Grilli and Curtis \(2021\)](#) recommend repeating the presentation of social norm messages over time to achieve long-term effects. For this repeated presentation, we believe our nudge intervention to be very suitable, as its design and wording is simple to adapt and expand.

7.2 General limitations and implications

Our study examined the effectiveness of a specific social norm intervention, with the aim of translating findings from behavioral science into a practical tool. It is important to consider that our study did not include any intervention control group. Therefore, we cannot say whether our effects are specific to our social norm nudge or whether other interventions would have been equally effective. Future studies should be devoted to comparing this intervention with other control groups (e.g., including dynamic norms, or normative appeals, [Sparkman et al., 2020](#)) to test the uniqueness of our social norm intervention.

Due to our observation method, all our data on gender and age are only estimated, and assumptions on education and socio-economic status were only assumed due to the context and not assessed. Given our data situation, we cannot make any clear statements about the individual effects of the respective socio-demographic characteristics of the sample on the effectiveness of the nudge. In general, confounding with the situation and field of application must be taken into account. Nevertheless, our results provide initial indications of the scalability of the intervention and enable concrete next steps in researching the intervention's success conditions.

Due to the observation method we have chosen, we cannot completely rule out demand effects that have amplified the nudge effect. However, we took great care to ensure that the experimenters observing the behavior were not conspicuous. Replication with other data collection methods (e.g., recording the average number of paper towels used at the end of a day over a longer period of time) would nevertheless be advisable in order to confirm the effect found.

Finally, our study focused primarily on behaviors that have a low impact on the environment or in the area of health promotion, which, while limiting the scope of interventions addressed, is still useful as these behaviors collectively account for a significant proportion of the overall environmental burden and public health related outcomes. It should also be emphasized that social norm interventions alone cannot be expected to bring about a complete change in behavior. Nudges influence decisions based on intuition rather than addressing the underlying motivation that drives a particular decision-making process (Bhargava and Loewenstein, 2015). However, social norm interventions can help to foster other traditional policy interventions and should be viewed in first place as complements to traditional measures (Benartzi et al., 2017).

8 Conclusion

In the present work, five field experiments testing the effectiveness and context dependency of a social norm nudge were presented. The applied social norm nudge Be-Like-Toni has shown to be effective in four of the five field experiments regarding paper towel reduction in a university as well as public restrooms and promoting voluntary mask wearing in a bakery. The social norm nudge has thus shown to be an effective, low-cost and easy-to-implement intervention motivating pro-environmental and pro-social behavior. The social nudge has shown to be implementable in different contexts and thus can be implemented into the real world by practitioners.

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/xg4h6/>.

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

DM: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. MB: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. TB: Writing – original draft, Methodology, Investigation. SG: Writing – original draft, Methodology, Investigation. AH: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. We acknowledge the funding from the University of Kassel library and the Department of Developmental Psychology at the Institute of Psychology of the University of Kassel for open access publication.

Acknowledgments

We thank Maibritt Budde, Miriam Eyer, Marie Grünwald, and Jule Kristanz for their idea and data collection of Experiment 1. Also, we thank Hannah Englisch, Iris Betzinger, Ann-Kathrin Fragemann, Isabell Vollmer, Sanja Schiele, Nele Beyer, Johanna Diez, Sebastian M. Maier, Tugba Cevik, Lena Pollok and Franziska Fuchs for their support in data collection of Experiments 2-5.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Aarestrup, S. C., Moesgaard, F., and Schuldt-Jensen, J. (2016). Nudging hospital visitors' hand hygiene compliance. Available at: <http://rgdoi.net/10.13140/RG.2.2.25911.52641>
- Abrahamse, W., and Steg, L. (2013). Social influence approaches to encourage resource conservation: a meta-analysis. *Glob. Environ. Chang.* 23, 1773–1785. doi: 10.1016/j.gloenvcha.2013.07.029
- Abrahamse, W., Steg, L., Vlek, C., and Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *J. Environ. Psychol.* 25, 273–291. doi: 10.1016/j.jenvp.2005.08.002
- Alexander, J. K., Hillier, A., Smith, R. M., Tivarus, M. E., and Beversdorf, D. Q. (2007). Beta-adrenergic modulation of cognitive flexibility during stress. *J. Cogn. Neurosci.* 19, 468–478. doi: 10.1162/jocn.2007.19.3.468

- Bao, H. X., and Lim, Y. (2022). Behavioural interventions for micro-mobility adoption: Low-hanging fruits or hard nuts to crack? *Transport. Res. F: Traffic Psychol. Behav.* 84, 423–441. doi: 10.1016/j.trf.2021.12.011
- Benartzi, S., Beshears, J., Milkman, K. L., Sunstein, C. R., Thaler, R. H., Shankar, M., et al. (2017). Should governments invest more in nudging? *Psychol. Sci.* 28, 1041–1055. doi: 10.1177/0956797617702501
- Bergquist, M., and Nilsson, A. (2016). I saw the sign: promoting energy conservation via normative prompts. *J. Environ. Psychol.* 46, 23–31. doi: 10.1016/j.jenvp.2016.03.005
- Bergquist, M., and Nilsson, A. (2019). The DOs and DON'Ts in social norms: a descriptive don't-norm increases conformity. *J. Theor. Soc. Psychol.* 3, 158–166. doi: 10.1002/jts5.43
- Best, E. L., Parnell, P., and Wilcox, M. H. (2014). Microbiological comparison of hand-drying methods: the potential for contamination of the environment, user, and bystander. *J. Hosp. Infect.* 88, 199–206. doi: 10.1016/j.jhin.2014.08.002
- Bhargava, S., and Loewenstein, G. (2015). Behavioral economics and public policy 102: beyond nudging. *Am. Econ. Rev.* 105, 396–401. doi: 10.1257/aer.p20151049
- Blackwell, C., Goya-Tocchetto, D., and Sturman, Z. (2017). Nudges in the restroom: How hand-washing can be impacted by environmental cues. Available at: <https://ssrn.com/abstract=3007866>
- Brehm, J. W. (1966). *A theory of psychological reactance*. New York: Academic Press.
- Byerly, H., Balmford, A., Ferraro, P. J., Hammond Wagner, C., Palchak, E., Polasky, S., et al. (2018). Nudging pro-environmental behavior: evidence and opportunities. *Front. Ecol. Environ.* 16, 159–168. doi: 10.1002/fee.1777
- Cialdini, R. B., Demaine, L. J., Sagarin, B. J., Barrett, D. W., Rhoads, K., and Winter, P. L. (2006). Managing social norms for persuasive impact. *Soc. Infl.* 1, 3–15. doi: 10.1080/15534510500181459
- Cialdini, R. B., Reno, R. R., and Kallgren, C. A. (1990). A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places. *J. Pers. Soc. Psychol.* 58, 1015–1026. doi: 10.1037/0022-3514.58.6.1015
- Costa-Font, J., Just, D. R., Fasolo, B., and Powdthavee, N. (2014). Nudging ourselves? The limits of incentivizing “good behavior”. *Appl. Econ. Perspect. Policy* 36, 1–5. doi: 10.1093/aep/ppt035
- COVID-19 Snapshot Monitoring. (2023). Explorer. Available at: <https://projekte.unierfurt.de/cosmo2020/web/explorer/>
- Croituru, E., and Nath, D. (2016). *Be like bill: the internet's smartest sensation*. London: Ebury Press.
- Czajkowski, M., Zagórska, K., and Hanley, N. (2019). Social norm nudging and preferences for household recycling. *Resour. Energy Econ.* 58:101110. doi: 10.1016/j.reseneeco.2019.07.004
- Czap, N. V., Czap, H. J., Khachaturyan, M., and Burbach, M. E. (2018). Comparing female and male response to financial incentives and empathy nudging in an environmental context. *Rev. Behav. Econ.* 5, 61–84. doi: 10.1561/105.00000079
- Dannenberg, A., Gutsche, G., Batzke, M. C. L., Christens, S., Engler, D., Mankat, F., et al. (2024). The effects of norms on environmental behavior. *Rev. Environ. Econ. Policy* 18, 165–187. doi: 10.1086/727588
- Dannenberg, A., and Weingärtner, E. (2023). The effects of observability and an information nudge on food choice. *J. Environ. Econ. Manag.* 120:102829. doi: 10.1016/j.jeem.2023.102829
- DellaVigna, S., and Linos, E. (2022). RCTs to scale: comprehensive evidence from two nudge units. *Econometrica* 90, 81–116. doi: 10.3982/ECTA18709
- Dorigoni, A., and Bonini, N. (2023). Water bottles or tap water? A descriptive-social-norm based intervention to increase a pro-environmental behavior in a restaurant. *J. Environ. Psychol.* 86:101971. doi: 10.1016/j.jenvp.2023.101971
- Faul, F., Erdfelder, E., Lang, A.-G., and Buchner, A. (2007). G*power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods* 39, 175–191. doi: 10.3758/BF03193146
- Festinger, L. (1954). A theory of social comparison processes. *Human* 7, 117–140. doi: 10.1177/001872675400700202
- Goldstein, N. J., Cialdini, R. B., and Griskevicius, V. (2008). A room with a viewpoint: using social norms to motivate environmental conservation in hotels. *J. Consum. Res.* 35, 472–482. doi: 10.1086/586910
- Grilli, G., and Curtis, J. (2021). Encouraging pro-environmental behaviours: a review of methods and approaches. *Renew. Sust. Energ. Rev.* 135:110039. doi: 10.1016/j.rser.2020.110039
- Hanna, P. J., Richardson, B. J., and Marshall, M. (1996). A comparison of the cleaning efficiency of three common hand drying methods. *Appl. Occup. Environ. Hyg.* 11, 37–43. doi: 10.1080/1047322X.1996.10389121
- Heiman, S. L., Claessens, S., Ayers, J. D., Guevara Beltrán, D., van Horn, A., Hirt, E. R., et al. (2023). Descriptive norms caused increases in mask wearing during the COVID-19 pandemic. *Sci. Rep.* 13:1856. doi: 10.1038/s41598-023-38593-w
- Hoffner, C. A. (2020). “Same-gender characters: appeal and identification” in *The international encyclopedia of media psychology*. ed. J. Bulck (New York: Wiley), 1–5.
- Howard, J., Huang, A., Li, Z., Tufekci, Z., Zdimal, V., and van der Westhuizen, H.-M. (2021). An evidence review of face masks against COVID-19. *Proc. Natl. Acad. Sci. USA* 118:e2014564118. doi: 10.1073/pnas.2014564118
- Huang, C., Ma, W., and Stack, S. (2012). The hygienic efficacy of different hand-drying methods: a review of the evidence. *Mayo Clin. Proc.* 87, 791–798. doi: 10.1016/j.mayocp.2012.02.019
- Janoff-Bulman, R., Sheikh, S., and Hepp, S. (2009). Proscriptive versus prescriptive morality: two faces of moral regulation. *J. Pers. Soc. Psychol.* 96, 521–537. doi: 10.1037/a0013779
- Jensen, M. S., Yao, R., Street, W. N., and Simons, D. J. (2011). Change blindness and inattention blindness. *Wiley Interdiscip. Rev. Cogn. Sci.* 2, 529–546. doi: 10.1002/wcs.130
- Kauertz, B., Schlecht, S., Markwardt, S., Rubik, F., Heinisch, J., Kolbe, P., et al. (2019). *Untersuchung der ökologischen Bedeutung von Einweggetränkebechern im Außer-Haus-Verzehr und mögliche Maßnahmen zur Verringerung des Verbrauchs*. Dessau, Germany: Federal Environment Agency.
- Keizer, K., Lindenberg, S., and Steg, L. (2008). The spreading of disorder. *Science* 322, 1681–1685. doi: 10.1126/science.1161405
- Lee, K., Abbott, A., Waraich, L., and Poulin, E. (2020). Using social influence to reduce paper towel use in university washrooms. Available at: <https://journals.kpu.ca/index.php/KPSJ/article/view/495>
- Lee, C. M., Geisner, I. M., Lewis, M. A., Neighbors, C., and Larimer, M. E. (2007). Social motives and the interaction between descriptive and injunctive norms in college student drinking. *J. Stud. Alcohol Drugs* 68, 714–721. doi: 10.15288/jsad.2007.68.714
- Lehner, M., Mont, O., and Heiskanen, E. (2016). Nudging – a promising tool for sustainable consumption behaviour? *J. Clean. Prod.* 134, 166–177. doi: 10.1016/j.jclepro.2015.11.086
- Leoniak, K. J., and Maj, K. (2016). A slice of hygiene: justification and consequence in the persuasiveness of prescriptive and proscriptive signs. *Soc. Infl.* 11, 271–283. doi: 10.1080/15534510.2016.1267663
- Loschelder, D. D., Siepelmeyer, H., Fischer, D., and Rubel, J. A. (2019). Dynamic norms drive sustainable consumption: norm-based nudging helps café customers to avoid disposable to-go-cups. *J. Econ. Psychol.* 75:102146. doi: 10.1016/j.joep.2019.02.002
- Mack, A. (2003). Inattention blindness: looking without seeing. *Curr. Dir. Psychol. Sci.* 12, 180–184. doi: 10.1111/1467-8721.01256
- Maier, M., Bartoš, F., Stanley, T. D., Shanks, D. R., Harris, A. J., and Wagenmakers, E. J. (2022). No evidence for nudging after adjusting for publication bias. *Proc. Natl. Acad. Sci.* 119:e2200300119. doi: 10.1073/pnas.2200300119
- Mertens, S., Herberz, M., Hahnel, U. J. J., and Brosch, T. (2022). The effectiveness of nudging: a meta-analysis of choice architecture interventions across behavioral domains. *Proc. Natl. Acad. Sci. USA* 119:e2107346118. doi: 10.1073/pnas.2107346118
- Mobekk, H., and Stokke, L. (2020). Nudges emphasizing social norms increased hospital visitors' hand sanitizer use. *Behav. Sci.* 6, 51–57. doi: 10.1177/237946152000600207
- Mollen, S., Holland, R. W., Ruiter, R. A. C., Rimal, R. N., and Kok, G. (2021). When the frame fits the social picture: the effects of framed social norm messages on healthy and unhealthy food consumption. *Commun. Res.* 48, 346–378. doi: 10.1177/0093650216644648
- Moseley, A., and Stoker, G. (2013). Nudging citizens? Prospects and pitfalls confronting a new heuristic. *Resour. Conserv. Recycl.* 79, 4–10. doi: 10.1016/j.resconrec.2013.04.008
- Nolan, J. M., Schultz, P. W., Cialdini, R. B., Goldstein, N. J., and Griskevicius, V. (2008). Normative social influence is underdetected. *Pers. Soc. Psychol. Bull.* 34, 913–923. doi: 10.1177/0146167208316691
- Pavey, L., Churchill, S., and Sparks, P. (2021). Proscriptive injunctions can elicit greater reactance and lower legitimacy perceptions than prescriptive injunctions. *Pers. Soc. Psychol. Bull.* 48, 676–689. doi: 10.1177/01461672211021310
- Pavey, L., Churchill, S., and Sparks, P. (2023). Perceived legitimacy can moderate the effect of proscriptive versus prescriptive injunctions on intentions to comply with UK government COVID-19 guidelines and reactance. *J. Appl. Soc. Psychol.* 53, 432–442. doi: 10.1111/jasp.12950
- Pavey, L., Sparks, P., and Churchill, S. (2018). Proscriptive vs. prescriptive health recommendations to drink alcohol within recommended limits: effects on moral norms, reactance, attitudes, intentions and behaviour change. *Alcohol Alcohol.* 53, 344–349. doi: 10.1093/alcalc/agx123
- Presseagentur, Deutsche. (2022). Freiwillig Masken in Innenräumen tragen. Weniger Beschränkungen [Voluntarily wear masks indoors. Fewer restrictions]. Available at: <https://www.pharmazeutische-zeitung.de/freiwillig-masken-in-innenraeumen-tragen-132348/>
- R Core Team. (2021). R: a language and environment for statistical computing. Available at: <https://www.R-project.org/>
- Schubert, C. (2017). Green nudges: do they work? Are they ethical? *Ecol. Econ.* 132, 329–342. doi: 10.1016/j.ecolecon.2016.11.009
- Schultz, P. W., Khazian, A. M., and Zaleski, A. C. (2008). Using normative social influence to promote conservation among hotel guests. *Soc. Infl.* 3, 4–23. doi: 10.1080/15534510701755614

- Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., and Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychol. Sci.* 18, 429–434. doi: 10.1111/j.1467-9280.2007.01917.x
- Smith, J. R., Louis, W. R., Terry, D. J., Greenaway, K. H., Clarke, M. R., and Cheng, X. (2012). Congruent or conflicted? The impact of injunctive and descriptive norms on environmental intentions. *J. Environ. Psychol.* 32, 353–361. doi: 10.1016/j.jenvp.2012.06.001
- Sparkman, G., Howe, L., and Walton, G. (2020). How social norms are often a barrier to addressing climate change but can be part of the solution. *Behav. Public Policy* 5, 528–555. doi: 10.1017/bpp.2020.42
- Starcke, K., and Brand, M. (2012). Decision making under stress: a selective review. *Neurosci. Biobehav. Rev.* 36, 1228–1248. doi: 10.1016/j.neubiorev.2012.02.003
- Sunstein, C. R. (2014). Nudging: a very short guide. *J. Consum. Policy* 37, 583–588. doi: 10.1007/s10603-014-9273-1
- Szaszi, B., Palinkas, A., Palfi, B., Szollosi, A., and Aczel, B. (2018). A systematic scoping review of the choice architecture movement: toward understanding when and why nudges work. *J. Behav. Decis. Mak.* 31, 355–366. doi: 10.1002/bdm.2035
- Thaler, R. H., and Sunstein, C. R. (2008). *Nudge: improving decisions about health, wealth, and happiness*. London: Yale University Press.
- Umweltbundesamt. (1993). Händetrocknungssysteme: Vergleichende ökologische Betrachtung unterschiedlicher Systeme zum Abtrocknen der Hände. Available at: <https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3179.pdf>
- van Valkengoed, A. M., Abrahamse, W., and Steg, L. (2022). To select effective interventions for pro-environmental behaviour change, we need to consider determinants of behaviour. *Nat. Hum. Behav.* 6, 1482–1492. doi: 10.1038/s41562-022-01473-w
- Varotto, A., and Spagnolli, A. (2017). Psychological strategies to promote household recycling. A systematic review with meta-analysis of validated field interventions. *J. Environ. Psychol.* 51, 168–188. doi: 10.1016/j.jenvp.2017.03.011
- Venema, T. A. G., Kroese, F. M., and Ridder, D. T. D. (2018). I'm still standing: a longitudinal study on the effect of a default nudge. *Psychol. Health* 33, 669–681. doi: 10.1080/08870446.2017.1385786
- Wee, S.-C., Choong, W.-W., and Low, S.-T. (2021). Can “nudging” play a role to promote pro-environmental behaviour? *Environ. Chall.* 5:100364. doi: 10.1016/j.envc.2021.100364
- White, K. M., Smith, J. R., Terry, D. J., Greenslade, J. H., and McKimmie, B. M. (2009). Social influence in the theory of planned behaviour: the role of descriptive, injunctive, and in-group norms. *Br. J. Soc. Psychol.* 48, 135–158. doi: 10.1348/014466608X295207
- Yamane, T., and Kaneko, S. (2021). Is the younger generation a driving force toward achieving the sustainable development goals? Survey experiments. *J. Clean. Prod.* 292:125932. doi: 10.1016/j.jclepro.2021.125932
- Zhang, J., and Jin, H. (2023). Nudging vaccination against COVID-19: a systematic review and meta-analysis. *Res. Sq.* 1:21203. doi: 10.21203/rs.3.rs-2430314/v1



OPEN ACCESS

EDITED BY

Giuseppe Carrus,
Roma Tre University, Italy

REVIEWED BY

Yue Ting,
China University of Mining and Technology,
China
Glenda Garza-Teran,
University of Sonora, Mexico

*CORRESPONDENCE

Chan L. Thai
✉ cthai@scu.edu

RECEIVED 26 January 2024

ACCEPTED 19 July 2024

PUBLISHED 31 July 2024

CITATION

Varni A, Thai CL and Jamaledine S (2024)
Using an Instagram campaign to influence
knowledge, subjective norms, perceived
behavioral control, and behavioral intentions
for sustainable behaviors.
Front. Psychol. 15:1377211.
doi: 10.3389/fpsyg.2024.1377211

COPYRIGHT

© 2024 Varni, Thai and Jamaledine. This is
an open-access article distributed under the
terms of the [Creative Commons Attribution
License \(CC BY\)](#). The use, distribution or
reproduction in other forums is permitted,
provided the original author(s) and the
copyright owner(s) are credited and that the
original publication in this journal is cited, in
accordance with accepted academic
practice. No use, distribution or reproduction
is permitted which does not comply with
these terms.

Using an Instagram campaign to influence knowledge, subjective norms, perceived behavioral control, and behavioral intentions for sustainable behaviors

Alexander Varni, Chan L. Thai* and Sandra Jamaledine

Department of Communication, Santa Clara University, Santa Clara, CA, United States

Introduction: Climate change poses one of the most pervasive threats to the planet today. Intervention is required to promote pro-environmental behaviors among individuals to curb its effects. Borrowing several constructs from the Theory of Planned Behavior, we designed and evaluated a campaign, delivered primarily through Instagram, to shift sustainability-related cognitions and behaviors among university students.

Methods: An online survey was distributed to undergraduate students at a Northern California university and collected responses from 1,552 participants.

Results: Comparing students who self-reported exposure to the campaign with those who were not exposed, students who observed the campaign materials had more knowledge about ($p < .001$), greater perceived social norms about ($p < .001$), and greater intentions to perform sustainable behaviors ($p < .001$). There were also increases in sustainable behaviors during the campaign, compared to the previous academic term.

Discussion: Implementing campaigns inspired by behavior change theories may be one viable strategy to increase individual sustainable behaviors for climate change mitigation.

KEYWORDS

climate change, theory of planned behavior, behavior change intervention, university students, Instagram

Introduction

One of the greatest crises facing our planet today is the threat posed by global climate change. The harmful effects of climate change range from sea level rise and biodiversity loss to increases in the frequency of extreme weather events and the spread of infectious diseases (Intergovernmental Panel on Climate Change, 2019, 2020, 2021; World Health Organization, 2020). Climate change also presents numerous threats for human communities, which range from immediate threats, like injury, death, and property damage associated with extreme weather events, to more prolonged threats: like decreases in agricultural productivity and food shortages associated with prolonged droughts (Intergovernmental Panel on Climate Change, 2019, 2020, 2021).

Mitigation measures have not kept up with these rapid changes. While institutional policy solutions play an important role in improving global sustainability practices, the actions of

individuals can also greatly contribute to sustainability efforts (Intergovernmental Panel on Climate Change, 2014, 2019). Thus, motivating individual behavioral change en masse will be an important aspect of meeting sustainability goals (Intergovernmental Panel on Climate Change, 2014). Taking into account readiness levels for behavior change and shifting the cognitive processes underlying behavior change is one possible route toward more sustainable behaviors (Wakefield et al., 2010). College students may have more positive attitudes surrounding sustainable behaviors (Carducci et al., 2021), and may hold heightened levels of awareness about climate change (Mazo and San Juan, 2019). Further, recent research has suggested that college students may be an important audience for pro-environmental behavior interventions, and that educational institutions could play a role in motivating sustainable behaviors (Yusliza et al., 2020; Kousar et al., 2022; Song et al., 2022). A greater understanding of what types of interventions are effective in promoting pro-environmental behaviors among individuals is needed. Accordingly, the purpose of this study is to evaluate a virtual campaign, which borrowed several constructs from the Theory of Planned Behavior, designed to encourage sustainable behaviors among college students.

Literature review

Individual behaviors for sustainability

Individual actions can be taken to improve sustainability, such as reducing food waste, eating plant-rich diets, taking public transit, carpooling, and recycling (Intergovernmental Panel on Climate Change, 2019, 2020; Landholm et al., 2019; Murray and DiGiorgio, 2021). These strategies are helpful and important, but they are not being implemented at great enough scales (Cotton et al., 2016; Intergovernmental Panel on Climate Change, 2019, 2020; Murray and DiGiorgio, 2021). Thus, mass communication interventions that could potentially shift a large group of people to engage in sustainability behaviors are necessary to create the scale of change needed to address this crisis. Mass media campaigns have been used to successfully alter the health behaviors of target populations, such as smoking (Bala et al., 2008; National Cancer Institute, 2008), cancer screenings (Baron et al., 2008), and heart disease prevention (Fortmann et al., 1986), among others (Wakefield et al., 2010). Their use for encouraging sustainability-related behaviors is a burgeoning area of research. Reaching receptive audiences who may be more ready to change can be a key factor to success in behavior change campaigns (Prochaska and Velicer, 1997).

College students and sustainability

Undergraduate university students are an important target audience that may be more receptive to changing their behaviors in relation to climate change (Sinatra et al., 2012; Li, 2014; Kousar et al., 2022; Li et al., 2022; Song et al., 2022). Several studies suggest that undergraduate students who are exposed to information about the climate crisis may: (1) hold increased awareness of the issues associated with climate change, and (2) be open to learning more about climate change (Sinatra et al., 2012; Aksit et al., 2017).

Furthermore, some research has shown a connection between increased understanding of climate change and increased sustainability behaviors among university students (Sinatra et al., 2012; Mazo and San Juan, 2019; Kousar et al., 2022), and has identified the potential of educational programs and interventions to motivate sustainable behaviors among students (de Vreede et al., 2014; Li, 2014; Yusliza et al., 2020; Li et al., 2022). Sinatra et al. (2012) found that when exposed to IPCC data, students were more receptive to learning about the topic and more willing to take action to reduce their individual carbon footprints. Kousar et al. (2022) echoed this, finding that heightened levels of climate change awareness among university students can lead to increased sustainable behaviors. The studies by Song et al. (2022) and Li et al. (2022) build upon these ideas in their discussions by noting the role that higher education institutions can play in promoting and fostering sustainable behaviors among university students.

Instagram in behavior change campaigns

A majority (71%) of 18- to 29-year-olds say they use Instagram (Pew Research Center, 2021), making the platform an apt choice to target college students. Given that this campaign was implemented during the COVID-19 pandemic, when students were learning remotely and opportunities to engage in person were not available, the use of a social media platform, such as Instagram, was even more important to increase engagement. The use of Instagram in communication campaigns designed to promote and sustain positive health behaviors is well-documented (Santarossa and Woodruff, 2018; Pilgrim and Bohnet-Joschko, 2019). Instagram has also been utilized as a communication tool for large public health authorities, like the Centers for Disease Control and Prevention (CDC; Kim and Kim, 2020).

Utilization of Instagram to promote positive behaviors among a target audience of university students has achieved notable success. Al-Eisa et al. (2016) found that Instagram was an effective tool for both motivating and maintaining healthy levels of physical activity among college students. While the above-mentioned studies are health behavior interventions that are not directly related to the topic of climate change, the findings from these studies are relevant to this campaign because they demonstrate the idea that Instagram can be used effectively as a tool to promote, motivate, and maintain positive behavioral changes among university students.

Theory of planned behavior constructs

We borrowed constructs from the Theory of Planned Behavior (TPB; Ajzen, 1991) to develop this campaign. The TPB argues that in order to alter the behavior of a target audience, a campaign must be able to affect a change in the behavioral intentions of that target audience (Ajzen, 1991; Ajzen, 2020). In other words, behavioral intention is positioned as the most proximate, direct predictor of behavior (Ajzen, 2020). Behavioral intention refers to “the motivational factors that influence a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior” (Ajzen, 1991, p. 188–189). The other constructs within the theory (attitudes,

subjective norms, and perceived behavior control) are assumed to influence behavioral intent that, in turn, influences behavior, with intention as the immediate antecedent of behavior (Ajzen, 1991; Ajzen, 2020). Attitudes refer to “the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question,” subjective norms are “the perceived social pressure to perform or not to perform the behavior,” and perceived behavioral control is defined as “the perceived ease or difficulty of performing the behavior” (Ajzen, 1991, p. 188). In addition to predicting behaviors, the TPB has proven to be successful in informing the design of behavior change interventions targeting groups (Steinmetz et al., 2016). Our campaign, inspired by these TPB constructs, aimed to influence the subjective norms and perceived behavior control of our target audience to affect a change in behavioral intent and a subsequent change in the target behavior.

Pro-environmental behaviors and the TPB constructs

Constructs from the TPB have been used extensively to measure and to predict pro-environmental behaviors (Heath and Gifford, 2002; Bamberg et al., 2003; Tikir and Lehmann, 2011; Greaves et al., 2013; Lin, 2013; de Leeuw et al., 2015; Elias et al., 2019; Pop et al., 2020; Aziz et al., 2021). In their study focusing on social media and sustainable purchasing behaviors, Pop et al. (2020) demonstrated the predictive ability of constructs from the TPB on intention to purchase green products. Meanwhile, Tikir and Lehmann (2011) demonstrated the effect of several TPB constructs on intentions to perform climate-friendly transportation behaviors. Further, the study by Aziz et al. (2021) builds upon these ideas, reiterating the ability of several TPB constructs to predict intentions toward sustainable behaviors among employees in a university context.

University students and the TPB constructs

Constructs from the TPB have also been widely used in interventions within populations of university students (Namkoong et al., 2017; Record et al., 2017; Norman et al., 2018). Parrott et al. (2008) highlighted the potential for using TPB constructs to guide web-based interventions targeting college students. The TPB constructs have also been used to great effect in campaigns aimed at reducing binge drinking (Norman et al., 2018) and reducing smoking behaviors (Namkoong et al., 2017; Record et al., 2017) among university students. In particular, Namkoong et al. (2017) highlighted the role that subjective norms played in influencing behavioral change during their anti-smoking intervention. Accordingly, we did not necessarily design this study to test the TPB, but rather used TPB constructs as a guide to design the campaign materials, with the goal of the study being to evaluate the effectiveness of the campaign in changing behavior and in shifting cognitions related to the TPB constructs.

Rationale and hypotheses

With growing concerns about the impacts of climate change, efforts to change individual behaviors at a larger scale need to be undertaken. We aimed to alter the constructs of subjective norms and perceived behavioral control in our target population to affect a change in behavioral intentions, and a subsequent change in behavior.

While we recognize that past scholarship has divided normative beliefs into various subcategories - e.g. injunctive beliefs and descriptive beliefs - (Ajzen, 2020), in the present study, we decided to conceptualize and assess subjective norms as one holistic construct. We did so following the precedent set by previous scholarship which studied the TPB constructs in relation to sustainable behaviors (Bamberg et al., 2003; Greaves et al., 2013; Pop et al., 2020). Accordingly, we proposed the following hypotheses to evaluate the effectiveness of our TPB-inspired campaign.

H1: Compared to those who were not exposed to the campaign, those exposed to the campaign will show greater:

- a Perceptions of subjective norms about engaging in sustainable behaviors.
- b Perceived behavioral control over engaging in sustainable behaviors.
- c Perceived behavioral intent to engage in sustainable behaviors in the future.
- d Actual knowledge about sustainable behaviors.
- e Perceived knowledge about sustainable behaviors.

We also anticipated that the number of sustainable behaviors self-reported via a campus website would be greater during the term while the campaign was running compared to the previous term, which was how our campus partner gaged sustainable behaviors on campus.

H2: The number of sustainable behaviors self-registered by campus community members will be greater during the academic term of the campaign compared to the previous academic term.

Materials and methods

Campaign description

This study was part of a student-based project at a small liberal arts university (~5,500 undergraduates, ~3,000 graduates) in Northern California in which senior class communication students were paired with a campus organization to develop and evaluate a campaign based on a behavior change theory and the goals and objectives of the campus partner. We collaborated with The Center for Sustainability, an organization on campus specifically focused on promoting sustainability at the University and in the community. The campus partner leads a number of initiatives aimed at promoting sustainability. Inside the classroom, the organization works with professors in order to integrate sustainability into the curriculum of classes across the university. Outside of the classroom, the organization hosts programs ranging from a student ambassador training program to an on-campus organic garden. The campus partner had also obtained a notable presence on social media with 2,171 followers on Instagram, 2,232 followers on Twitter, and a newsletter that reaches over 6,700 recipients monthly.

The campus partner has a branded program called the Sustainability Playbooks where they recommend 50+ sustainability behaviors across nine domains. Each behavior is correlated with one

TABLE 1 Communication materials.

TPB construct	Post type	Number of posts	Example
Subjective Norms	Sustainability Icon Video	5	Our first video aimed to promote plant-based food consumption. The video highlights key ingredients and provides a tutorial for preparing a plant-based recipe.
	Instagram Feed Post	2	We designed an image showcasing a woman riding a bike through a green space in a city. This digital illustration also included the transportation badge icon from the Sustainability Playbooks program to highlight the association of this behavior with the transportation domain of the Playbooks.
	Instagram Story Post	2	
PBC	Instagram Feed Post	2	We designed a story post that showcased a woman standing near a refrigerator in front of a blue background. The post included the following text: “It’s so easy to earn an Energy Playbook badge!” The post also included the badge icon for the energy domain of the Playbooks.
	Instagram Story Post	2	
	Flyer	4	The flyer included a short message explaining the Sustainability Playbooks program as simple and easy actions which can be used to mitigate climate change.

of the SDGs, representing a local contextualization of the overarching climate change mitigation goals that is specifically suited to the campus and student population. While some of these sustainable behaviors involve political and community action that may eventually affect institutional level change, the core of every recommended sustainable behavior lies in individual action. For example, the “transportation” domain includes a recommended behavior which encourages individuals to walk or ride their bike for their commute instead of driving a car. One of the key components of this program is a web portal wherein students and other campus community members can register their completion of the recommended sustainability behaviors.

Given the extensive work of The Center for Sustainability, internal data from the Office of Institutional Research between 2015 and 2019 has consistently shown that over 90% of students show positive attitudes toward sustainability, and over 60% of students believe that individuals can do something to make a difference.¹ Accordingly, our campaign did not target attitudes about sustainability, and focused on motivating the student population to implement these recommended individual sustainable behaviors.

Communication materials designed for the campaign were mapped onto one of the various constructs from the TPB, including: 5 “Sustainability Icon” videos (subjective norms), 4 Instagram story posts (2 corresponding to PBC and 2 corresponding to subjective norms), and 4 Instagram feed posts (2 corresponding to PBC and 2 corresponding to subjective norms; see Table 1). For example, the video content reflected the concept of subjective norms by showcasing students completing sustainability behaviors, in order to present the behaviors as fun, popular activities that align with the culture of our campus community. The various subjective norms posts also focused on the fact that completing the behaviors will allow students to earn “sustainability badges,” messaging which was intended to highlight the badges as a form of status symbol connected to the environmentally

sustainable norms of the campus community. On the other hand, the materials corresponding to PBC highlighted the sustainability behaviors as easy and quick actions: with phrases like “It’s so easy to earn an Energy Playbook badge!” Further, while the communication materials for the first week of the campaign promoted the sustainability behaviors program in general – without specifying a specific recommended behavior – the following 3 weeks promoted the purchasing, transportation, and energy domains, respectively.

Our communication materials were primarily distributed on Instagram by our campus partner, as well as 6 student-led organizations, who “reposted” our content, over the course of 4 weeks. These student organizations also promote pro-environmental missions, allowing them to leverage their existing networks to further the reach of our materials. Additionally, the campaign included one virtual flyer, targeting the construct of PBC, which was distributed via email listservs to student mailing lists.

Participants/data

Exposure to campaign

The campaign was carried out on the public Instagram accounts of our campus partner and of our 6 student-led organizations, meaning that anyone could visit the pages and be potentially exposed to the campaign materials. At the time of the campaign, the combined reach of the participating Instagram accounts was ~4,250 followers. Flyers were also distributed via various student email listservs, many of which registered students are automatically enrolled.

Evaluation study

Through collaboration with the Office of Assessment at the University, our campaign evaluation measures were included on a regularly scheduled student-body-wide campus wellness assessment. The Institutional Review Board of the University approved the study before data collection began. An email invitation to complete the survey was sent out to all registered undergraduate students (N=5,505) describing the purpose of the study and providing instructions on how to complete the survey. Those students who chose to participate were directed to a consent form. Once consent was given, participants completed 60 items on the survey. While the 60

1 Data from 2015, 2017, and 2019 show that over 90% of students agree that they have a personal responsibility to make a difference on sustainability related issues, and over 60% disagreed that there was little individuals can do to make a difference in sustainability.

total survey items on the assessment covered a range of topics relating to wellness and life on campus, we utilized only the demographics data and the data from the specific measures relating to the present study in our analysis (see Table 2). 1,552 participants completed the survey for a response rate of 28%. Records were also gathered from our campus partner on registered sustainability behaviors. The data that support the findings of this study are openly available in figshare [<https://doi.org/10.6084/m9.figshare.16583600.v1>].

Measures

Independent variable

Campaign exposure

Campaign exposure was assessed using a self-report item (see Table 2) with no, yes, and not sure as the possible response options. We decided to use three exposure categories because the “not sure” group is qualitatively different from a definitive “no” or a definitive “yes” in terms of recognition of exposure to the campaign.

Dependent variables

Subjective norms

Participants responded to a set of statements utilizing a 7-point, interval level, Likert-type scale (see Table 2). The first two measures were adapted from Bamberg et al. (2003) and the third measure was adapted from Han et al. (2010). The three items were combined to create a subjective norms scale (Cronbach's $\alpha = 0.88$).

Perceived behavioral control

For perceived behavioral control, participants responded to the three statements (Table 2). These measures for perceived behavioral control were adapted from Han et al. (2010)'s study. These items were combined to create a scale (Cronbach's $\alpha = 0.69$).

Behavioral intent

The measures designed to assess behavioral intent were also assessed on a 7-point, Likert-type scale (Table 2). These measures were also adapted from Han et al. (2010)'s study. These items were combined to create a scale for behavioral intent (Cronbach's $\alpha = 0.89$).

Actual knowledge

The actual knowledge measure for our survey (see Table 2) was recoded to indicate a correct answer to the question, such that the correct answer (option 1) was recoded as a “1” and the incorrect answers were coded to “0.”

Perceived knowledge

We also included a self-reported knowledge item in our survey materials (Table 2). Assessing awareness with both a self-reported and actual knowledge assessment helped to give us a more holistic picture of the effect that our campaign may have had on increasing awareness of the Sustainability Playbooks.

Behaviors

The data from our campus partner tracked the details of every sustainability behavior registered on their website. The data includes the following variables: Role (e.g., student, alumni, faculty, etc.),

Student Year (if applicable), and Date Completed. While the survey data were all collected from students on campus, the data on sustainability behaviors from our campus partner reflect the performance of sustainability behaviors registered by anyone in the campus community, including faculty, staff, alumni, and others.

Sociodemographics

In terms of demographic data, measures were included for the following categories: gender identity (*male, female, transgender female, transgender male, gender non-conforming, other, prefer not to answer*), race/ethnicity (*African-American/Black, Asian, Native Hawaiian/Pacific Islander, Caucasian/White, Hispanic/Latino, Spanish, Middle Eastern, Mixed Race, Other*), Housing Situation (*On-Campus Housing, Off-Campus Housing, In family home within US, In family home outside of US, other*), age (*years*), and class year (*first year, sophomore, junior, senior*).

Data analysis plan

Descriptive statistics were computed for sample demographics. One-way ANOVAs were computed to assess differences between the three exposure groups on our key outcomes of subjective norms, perceived behavioral control, behavioral intent, and perceived knowledge. Post-hoc tests (Sheffé) were then conducted to further assess differences between pairs of groups. For the actual knowledge item, we utilized the re-coded actual knowledge item to run a Chi-Square test in SPSS. All tests were conducted using SPSS 27, with a significance level set at $p < 0.05$. The data that support the findings of this study are available here: <https://doi.org/10.6084/m9.figshare.16583600.v1>.

Results

Descriptive results

Data were collected from 1,552 participants (28% response rate). Of these respondents, 29.1% were first-year students, 24.1% were Sophomores, 25.8% were Juniors, and 21.0% were Seniors (See Table 3). In terms of gender and race/ethnicity, the sample was 56.4% female and Caucasian/White (50.1%). With respect to geography, most students were living either off campus on their own (36.7%) or with their family (53.2%). The mean age of the sample population is 19.9 years old.

Exposure to campaign

When assessing exposure to the campaign materials, the participants were divided into three groups: Yes (Exposure Group), No (Non-exposure Group), and Unsure. The Exposure Group was the largest with 44.7% of respondents, followed by the Non-exposure Group at 31.0%, and the Unsure Group at 24.3%.

Subjective norms

The results from a one-way ANOVA showed that the Exposure Group reported the highest scores for subjective norms with a mean score of 5.93 (SD = 0.99; see Table 4). The Unsure Group reported the

TABLE 2 Measures.

Variables	Survey measures
Campaign Exposure	“Have you seen any information on campus-based social media accounts, newsletters, or other sources about The Center for Sustainability’s sustainability behaviors?” Yes / No / Not Sure
Subjective Norms	1. Most people who are important to me and whose opinions I value would support me completing recommended sustainability behaviors. 2. Most people who are important to me and whose opinions I value think that I should help to mitigate climate change by completing recommended sustainability behaviors 3. Most people who are important to me and whose opinions I value would encourage me to help mitigate climate change by completing recommended sustainability behaviors. Strongly Agree (1) / Strongly Disagree (7); Cronbach’s alpha = 0.88
Perceived Behavioral Control	1. Whether or not I complete a recommended sustainability behavior is completely up to me. 2. I am confident that if I want, I can complete a recommended sustainability behavior. 3. I have resources, time, and opportunities to complete a recommended sustainability behavior. Strongly Agree (1) / Strongly Disagree (7); Cronbach’s alpha = 0.69
Behavioral Intent	1. I am willing to complete a recommended sustainability behavior and earn a Badge from the Sustainability Center. 2. I plan to complete a recommended sustainability behavior and earn a Badge from the Sustainability Center. 3. I will make an effort to earn Badges from the Sustainability Center during my time at [redacted] Strongly Agree (1) / Strongly Disagree (7); Cronbach’s alpha = 0.89
Actual Knowledge	“What are the Sustainability Playbooks?” 1 = “A set of actions recommended by [redacted] Center for Sustainability that students can take to directly contribute to a more sustainable campus and world.” 2 = “A course at [redacted]” 3 = “A registered student organization at [redacted]” 4 = “Do not know.” This item was recoded to indicate a correct answer to the question, such that the correct answer (option 1) was recoded as a “1” and the incorrect answers were coded to “0.”
Perceived Knowledge	“Please choose the one best response: Over Winter Quarter, my knowledge about how I can engage in sustainability behaviors has...” 1 = “Stayed the same as before” 2 = “Increased slightly” 3 = “Increased somewhat” 4 = “Increased significantly”

second-highest scores for subjective norms, with a mean score of 5.66 (SD = 1.08). The Non-exposure Group reported the lowest scores for subjective norms, with a mean score of 5.54 (SD = 1.23). The difference in mean score between the Exposure Group and the Non-exposure Group was 0.39 [$F(2,717) = 7.86, p < 0.001$].

Post-hoc analyses using the Sheffe showed that subjective norms were greater in the Exposure Group compared to the Non-exposure Group ($p < 0.001$). Differences between the “Not Sure” vs. the Exposure Group and the “Not Sure” vs. the Non-exposure Group were not significant ($p = 0.06$ and $p = 0.55$, respectively). The Sheffe test was selected due to the unequal sample sizes, and because we did not have planned contrasts. Thus, H1a was supported.

Perceived behavioral control (PBC)

The Exposure Group reported the highest scores for PBC with a mean score of 5.71 (SD = 0.93), followed by the Unsure Group (5.47, SD = 1.03). The Non-exposure Group reported the lowest scores for PBC, with a mean score of 5.46 (SD = 1.16; see Table 4). The difference in mean score between the Exposure Group and the Non-exposure Group was 0.25 [$F(2, 516) = 2.59, p = 0.076$]. H1b was not supported.

Behavioral intent

The one-way ANOVA [$F(2, 717) = 24.88, p < 0.001$] showed that the Exposure Group reported the highest mean scores for behavioral intent (4.58, SD = 1.56; see Table 3). The Unsure Group reported the second-highest scores for behavioral intent (3.97, SD = 1.36), and the Non-exposure Group had the lowest scores (3.58, SD = 1.53). The difference in mean score between the Exposure Group and the Non-exposure Group was 1.00, which was the largest of any of the TPB constructs that we assessed. Post-hoc analyses using the Sheffe showed that behavioral intentions were greater in the Exposure Group compared to the Non-exposure Group ($p < 0.001$) as well as the Unsure Group ($p < 0.001$). Differences between the “Not Sure” vs. the Non-exposure Group was also significant ($p = 0.03$). Based on these results, H1c was also supported.

Actual knowledge

The Chi-Square analysis showed that the Exposure Group had the highest percentage of correct actual knowledge scores, at 48.9% [$X^2(2, N = 1,110) = 154.98, p < 0.0001$; Table 5]. The Non-exposure Group reported the second-highest percentage of correct actual knowledge

scores, at 29.3%. The Unsure Group scored the lowest percentage of correct actual knowledge scores, at 20.9%. Across all three groups, 44.8% of the sample population identified the correct answer. The

TABLE 3 Descriptive statistics ($n = 1,552$).

Gender	
Male	42.1%
Female	56.4%
Transgender Female	0.1%
Transgender Male	0.1%
Gender Non-conforming	0.7%
Other	0.2%
Preferred Not to Answer	0.4%
Race/Ethnicity	
African American / Black	3.2%
Asian	24.9%
Native Hawaiian / Pacific Islander	0.6%
Caucasian / White	50.1%
Hispanic/Latino/Spanish	10.8%
Middle Eastern	1.3%
Mixed Race	7.4%
Other	1.7%
Academic Year	
First-years	29.1%
Sophomores	24.1%
Juniors	25.8%
Seniors	21.0%
Housing Situation	
On-Campus Housing	4.4%
Off-Campus Housing	36.7%
In my family home or residence within the US	53.2%
In my family home or residence outside of the US	5.1%
Other	0.6%
Age	Mean = 19.95
	SD = 1.89
	Range = 17–51
Exposure to Campaign	
Yes	44.7%
No	31.0%
Not Sure	24.3%

TABLE 4 One-way ANOVA.

	Yes	Unsure	No	df	<i>F</i>	<i>n</i>	<i>p</i>
Subjective norms	5.93	5.66	5.54	2	7.86	720	0.000
PBC	5.71	5.47	5.46	2	2.59	519	0.076
Behavioral intent	4.58	3.97	3.58	2	24.8	633	0.000
Self-reported knowledge	1.72	1.43	1.39	2	20.9	1,109	0.000

The bold values represent the statistically significant of *p* values.

difference in percentage correct score between the Exposure Group and the Non-exposure Group was 19.6%. Post-hoc analyses using the Sheffe showed that knowledge was greater in the Exposure Group compared to the Non-exposure Group ($p < 0.001$) as well as the Unsure Group ($p < 0.001$). Differences between the “Not Sure” vs. the Non-exposure Group was also significant ($p = 0.04$). Thus, H1d was supported.

Self-reported knowledge

The results of the ANOVA [$F(2, 1,106) = 20.97, p < 0.0001$] for self-reported knowledge data show that the Exposure Group reported the highest levels of self-reported knowledge with a mean score of 1.72 out of 4 ($SD = 0.87$; Table 4). The Unsure Group reported the second-highest levels of self-reported knowledge, with a mean score of 1.43 ($SD = 0.68$). The Non-exposure Group reported the lowest levels of self-reported knowledge, with a mean score of 1.39 ($SD = 0.70$). The difference in mean score between the Exposure Group and the Non-exposure Group was 0.33. H1e was supported.

Behavior

We hypothesized that the number of self-reported sustainable behaviors on the registration database would be greater during the academic term of our campaign compared to the previous academic term. 48 behaviors were registered during the term featuring our campaign (Winter 2021), compared to 8 behaviors in the Fall 2020 term (Table 6). Hypothesis 2 was supported by our results.

Compared with other quarters of remote learning, the two quarters preceding our campaign had 14 behaviors (Spring 2020) and 8 behaviors (Fall 2020), respectively; the two subsequent quarters had 9 behaviors (Spring 2021) and 11 behaviors (Fall 2021), respectively. The academic quarter which featured our campaign (Winter 2021), saw 48 registered behaviors: higher than two previous and two subsequent quarters of remote learning (see Table 6).

Discussion

The purpose of this study was to assess the effectiveness of an Instagram campaign which utilized constructs from the Theory of Planned Behavior to promote sustainability behaviors among undergraduates. We found that of the 1,552 respondents on the survey, 44.7% reported seeing our campaign, 31% reported not seeing our campaign, and 24.3% were not sure. As has been suggested by Segerberg (2017), putting information about climate change online

TABLE 5 Actual knowledge chi square test.

	Total	Correct % (n)	Incorrect % (n)
Exposure (Yes)	344	49.8% (248)	15.7% (96)
Non-Exposure (No)	495	29.3% (146)	57.0% (248)
Not Sure	271	20.9% (104)	27.3% (167)

TABLE 6 Number of sustainable actions registered during COVID 19 remote learning.

Academic Term	Dates	# of Registered Behaviors
Spring 2020	30 Mar 2020–11 June 2020	14
Fall 2020	21 Sept 2020–11 Dec 2020	8
Winter 2021	4 Jan 2021–19 Mar 2021	48*
Spring 2021	29 Mar 2021–10 June 2021	9
Fall 2021	20 Sept 2021–10 Dec 2021	11

* indicates the academic quarter during which the communication campaign was conducted.

does not guarantee attention among the target audience; thus we believe a 44.7% self-reported exposure rate is reasonable.

We found that individuals who had been exposed to our campaign reported higher mean scores for subjective norms and behavioral intent compared to those who were not exposed to our campaign. Behavioral intent had the largest difference in mean score between the Exposure Group and Non-exposure Group. Those who were exposed to our campaign also showed greater knowledge about the target sustainability behaviors than those who were not exposed. While the differences between groups for subjective norms and knowledge were small, previous meta-analyses on media campaigns for health have shown similar effect sizes (see [Noar, 2007](#)). These findings provide evidence for the effect that our campaign may have had in increasing knowledge of, and intention to participate in, sustainable behaviors.

Conversely, the results for PBC had the smallest difference in mean score (0.25) and were not statistically significant ($p=0.076$). Previous studies that have utilized TPB constructs have also seen smaller effects for PBC than other constructs ([Namkoong et al., 2017](#); [Norman et al., 2018](#)). For example, the study by [Namkoong et al. \(2017\)](#) found that their intervention did not successfully affect the construct of PBC ($p=0.94$), despite having a significant impact on subjective norms ($p=0.05$). We suspect that we saw a smaller effect for PBC in our study partially due to the fact that we implemented the campaign during the COVID-19 pandemic. Looming financial concerns, lack of complete information about the effects of the virus, in addition to the isolation many faced, may have led to an overall generalized sense of lack of control ([Wnuk et al., 2020](#)), and may have influenced the sense of control over sustainable behaviors among our participants.

We also included observational data as a part of our study. While data from the sustainability behaviors registry did not directly match the number of participants who responded to the survey with intentions to engage in sustainable behaviors, the rate of increase in self-registrations of behavior during the time of the campaign was substantially greater than the previous term (48 in Winter 2021 compared to 8 in Fall 2020). The purchasing domain, which we targeted first, showed the highest number of actual registered behaviors during the campaign period: constituting 12 of the 48 total

registered behaviors. Further, 11 of those 12 purchasing behaviors were registered for the specific action that we promoted in our communication materials (consuming vegetarian or vegan meals). Although we also targeted the energy and transportation domains, the outcomes for these areas were less pronounced, with 2 and 1 registered behaviors, respectively.

Overall, these are much lower than the numbers from the previous academic year, however, we suspect that students learning remotely due to the COVID-19 pandemic may have tempered the enthusiasm and engagement for the program. Internal data from our Office of Assessment showed that about 30% of students had not participated in any campus activities after the end of the Fall 2020 quarter, during which we were fully remote. Reasons for this lack of participation included Zoom fatigue, overwhelm from coursework, and difficulty finding activities related to interests. Thus, the increase in the number of self-registered behaviors we saw from the previous term may be an even stronger indication of the campaign's success. Additionally, in a typical year, our campus partner held multiple on-campus events that could have contributed to increased participation in behaviors that qualified for registration. Early research on the effects of the COVID-19 pandemic at higher education institutions has shown decreased connection between students and their on-campus community, and changes to extracurricular participation ([Gonzalez-Ramirez et al., 2021](#); [Lederer et al., 2021](#)).

It is possible that participants engaged in sustainable behaviors, but did not register them. Each of the results we found for the TPB constructs lend their support to this idea and the findings for behavioral intent are particularly valuable in supporting this notion, as behavioral intent is the strongest predictor of actual behavior ([Ajzen, 1991](#); [Ajzen, 2020](#)). While we did not assess self-reported behaviors in the survey, correlational studies have consistently shown that intentions are reliably associated with behavior. In a meta-analysis of 185 studies that have used the TPB, the average correlation between measures of intention and behavior was .47 ([Armitage and Conner, 2001](#)). Additionally, a meta-analysis of experimental studies found that changes in intention lead to changes in behavior, though the size of this effect is considerably smaller than correlational tests have suggested ([Webb and Sheeran, 2006](#)). This may explain why even though we saw a high score on behavioral intention in our self-reported survey data, this did not necessarily translate into the observed behavioral registry data.

What we have offered here is not necessarily a test of the predictive power of the antecedent constructs of subjective norms and perceived behavioral control on behavioral intent, but rather, an evaluation of whether a communication campaign developed using constructs borrowed from the TPB, and delivered via Instagram, was effective in shaping the cognitive responses related to subjective norms, self-reported knowledge, and perceived behavioral intention to engage in sustainable behaviors of those who saw the campaign. Our results suggest that an Instagram campaign can work to move peoples' cognitions about engaging in sustainable behaviors in the desired direction. This echoes the success of decades of work in the use of media campaigns to change health behaviors (see [Wakefield et al., 2010](#)) and suggests that employing strategies from behavior change campaigns may be one avenue toward encouraging more behavior change with regard to sustainable behaviors to mitigate climate change.

Our campaign was a fully virtual campaign, delivered via Instagram and email listservs, which focused on a specific target

audience to engage in sustainable behaviors to mitigate climate change. A recent review of online and social media campaigns for climate change (Segeberg, 2017) highlighted that, “the study of online and social media campaigns to engage the public with climate change is still in its infancy” (p. 3). We are pleased to contribute work on what we believe to be one of the first studies to present an evaluation of a successful campaign to shift cognitions related to sustainable behaviors delivered via Instagram. This complements the wide range of work that has been done to raise awareness and shape scientific understanding among publics and mobilize citizens in pressuring decision makers to implement climate change mitigation policies (see Robelia et al., 2011; Senbel et al., 2014; Segeberg, 2017).

Our campaign targeted college students, because previous research has shown that they may hold favorable attitudes regarding sustainable behaviors (Carducci et al., 2021) and heightened levels of awareness about climate change (Jamelske et al., 2013; Wachholz et al., 2014; Aksit et al., 2017; Mazo and San Juan, 2019). Focusing on closely networked individuals, such as students on a college campus with a cohesive culture, as we have done in this campaign, aligns with work that has found linkages between networks, conversations within networks, and attitudes and beliefs about climate change. As Leombruni (2015) found, culturally grouped individuals talking about climate change can lead to others in the group to adopt the same opinions as projected by the group identity. College campuses present an ideal setting for sustainability and climate change campaigns; they culturally group individuals who already show an awareness of climate change (Mazo and San Juan, 2019), positive attitudes about sustainable behaviors (Carducci et al., 2021), and are networked together. We hope that our work can serve as a model for how to engage students on campuses across the world.

Limitations and future directions

One major limitation of this study is that, with the non-experimental design we utilized in our campaign, we were unable to effectively control for exposure and utilized a self-reported measure. We were also unable to collect pre-test data and compare to post-test data, resulting in a cross-sectional design. However, we believe our study still presents valuable findings and proposes a novel way for scholars, students, and sustainability-focused organizations to partner and work together.

Another limitation relates to the use of digital dissemination channels - while the vast majority of the campaign's communication materials were distributed via Instagram, there was one promotional flyer that was also distributed via email listservs to the student population. This distribution through various channels, along with resharing and reposting of Instagram materials made by the general student population, also represents a potential limitation for the study. With various user-focused algorithms at play, we could not control who viewed the campaign versus not, as well as who shared the materials versus not. However, the viewing and resharing of materials through various channels is a prevalent aspect of social networks and, while the lack of experimental control in this authentic online environment certainly constitutes a limitation, it adds to the study in other ways. Environmental communication, which aims to positively influence individual behaviors, is only valuable in that it can change the behaviors of everyday people in a real-world setting. The fact that

this campaign achieved success in the “real world,” outside of a controlled experimental setting, suggests strong external validity for the strategies we utilized in other real-world environments.

We also did not measure attitudes or self-reported behavior. For attitudes, we knew from internal data from the university that attitudes toward sustainability were already high among students; however, measuring this construct may have allowed us to conduct more rigorous analyses in testing the TPB as a model. For behaviors, we attempted to triangulate data from our campus partner to account for behavior; however, because the behaviors were self-reported via the registration database, we were unable to fully triangulate the results. Relatedly, with the use of the registration data and our non-experimental design, we were unable to ensure that the same specific participant individuals had registered behaviors in each of the respective academic terms; nor were we able to track specific individuals' changes in their number of registered behaviors in the database. In the future, we may measure self-reported behavior on our evaluation survey, as well as examine analytics data from the campus partner's website and Instagram accounts. We did not include analytics from Instagram in our formal evaluation plan, but future research should certainly take advantage of the potential for analytics that come from the campaign distribution platform, as these analytics could serve as an additional data point for exposure (see Grantham et al., 2021). Despite these limitations, our study makes an important contribution in helping us understand how college-campus based campaigns can be effective in shifting the cognitive processes underlying behavior change related to climate change mitigation efforts.

Practical implications

The findings from this study have a number of implications for behavior change interventions. First, our results highlight the utility of behavior change theories in the design of environmental communication interventions. While many studies have tested the TPB in relation to the topics of climate change and sustainable behaviors (Tikir and Lehmann, 2011; Lin, 2013; Aziz et al., 2021), very few have designed, executed, and evaluated actual climate change mitigation campaigns which drew from these theories. Our results suggest that TPB constructs can be utilized to inform successful communication interventions aimed at promoting sustainable behaviors. This has widespread implications for the use of behavioral change theories in environmental communication interventions; further investigation is warranted.

Our results have implications for the structure and execution of behavior change interventions and environmental communication practice in university contexts. Our study presents an evaluation of a communication campaign developed through a campus organization-student-faculty partnership. As the effects of climate change continue to worsen, universities and their community members are increasingly taking responsibility for assessing and reducing their own carbon footprints (Sippel et al., 2018; Clabeaux et al., 2020; Yusoff et al., 2021). The campaign evaluated in this study can serve as a model for colleges and universities aiming to reduce their carbon footprint and/or expand their on-campus sustainability efforts.

Beyond the student research team and faculty advisor, the distribution of our communication campaign involved one on-campus

partner organization and six on-campus student-led organizations, all of which already had large followings on Instagram or via email listservs. Identifying student organizations with large followings on campus and partnering with these organizations could be beneficial to increasing the reach of behavior change campaigns. The participation of students and on-campus organizations in the distribution of pro-environmental communication campaigns may also play a role in establishing pro-environmental norms on a university campus: potentially bolstering attempts to affect the construct of subjective norms with a communication intervention. Future research should explore additional avenues of engaging students and on-campus organizations in the design and implementation of pro-environmental behavior change communication interventions on college and university campuses.

Conclusion

As the climate crisis continues to worsen, more strategies to mitigate climate change are needed, including encouraging individuals to engage in actions that will lead to more sustainable lifestyles. Our campaign, developed with constructs borrowed from the Theory of Planned Behavior, and implemented via Instagram at a small liberal arts university, showed success in shifting sustainability-related cognitions and behaviors. Compared with the Non-exposure Group, participants with self-reported exposure to the campaign materials held higher subjective norms about and higher intent to perform sustainable behaviors, as well as greater knowledge of the sustainable behaviors promoted by the campaign. Additionally, observational data from an on-campus registry showed an increase in registered sustainable behaviors during the course of our campaign, when compared to the previous and subsequent academic terms of remote learning. We believe that our campaign can serve as a model for other universities in their efforts to promote individual sustainable behaviors in their local communities. With the motivation of sustainable behaviors en masse being a crucial aspect of mitigating climate change, our campaign provides a guide for future interventions performed at greater scales, among universities and the general public, which will forge a vital component of the global effort to combat the climate crisis.

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: <https://doi.org/10.6084/m9.figshare.16583600.v1>.

References

- Ajzen, I. (1991). The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50, 179–211. doi: 10.1016/0749-5978(91)90020-T
- Ajzen, I. (2020). The theory of planned behavior: frequently asked questions. *Hum. Behav. Emerg. Tech.* 2, 314–324. doi: 10.1002/hbe2.195
- Aksit, O., McNeal, K. S., Gold, A. U., Libarkin, J. C., and Harris, S. (2017). The influence of instruction, prior knowledge, and values on climate change risk perception among undergraduates. *J. Res. Sci. Teach.* 55, 550–572. doi: 10.1002/tea.21430
- Al-Eisa, E., Al-Rushud, A., Alghadir, A., Anwer, S., Al-Harbi, B., Al-Sughaier, N., et al. (2016). Effect of motivation by "Instagram" on adherence to physical activity among female college students. *Biomed. Res. Int.* 2016:1456013. doi: 10.1155/2016/1546013
- Armitage, C. J., and Conner, M. (2001). Efficacy of the theory of planned behaviour: a meta-analytic review. *Br. J. Soc. Psychol.* 40, 471–499. doi: 10.1348/014466601164939
- Aziz, F., Md Rami, A. A., Zaremohzzabieh, Z., and Ahrari, S. (2021). Effects of emotions and ethics on pro-environmental behavior of university employees: a model based on the theory of planned behavior. *Sustain. For.* 13:7062. doi: 10.3390/su13137062

Ethics statement

The studies involving humans were approved by Santa Clara University Institutional Review Board. The participants provided their electronic informed consent to participate in this study.

Author contributions

AV: Conceptualization, Investigation, Writing – original draft, Writing – review & editing. CT: Supervision, Writing – original draft, Writing – review & editing. SJ: Data curation, Project administration, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and authorship of this work. The publication of this work was supported by the Office of the Provost at Santa Clara University.

Acknowledgments

We would like to thank Lindsey Kalkbrenner, Cara Uy, and Lauren Hewitt at the Center for Sustainability at Santa Clara University for their collaboration. We would like to acknowledge Kaitlin Alayo and Nathan Otto for their contributions during the initial phases of the project. And we would like to thank the SCU on-campus student organizations that assisted in the dissemination of the campaign.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- Bala, M., Strzeszynski, L., and Cahill, K. (2008). Mass media interventions for smoking cessation in adults. *Cochrane Database Syst. Rev.* 1:CD004704. doi: 10.1002/14651858.cd004704.pub2
- Bamberg, S., Ajzen, I., and Schmidt, P. (2003). Choice of travel mode in the theory of planned behavior: the roles of past behavior, habit, and reasoned action. *Basic Appl. Soc. Psychol.* 25, 175–187. doi: 10.1207/S15324834BASP2503_01
- Baron, R. C., Rimer, B. K., Breslow, R. A., Coates, R. J., Kerner, J., Melillo, S., et al. (2008). Client-directed interventions to increase community demand for breast, cervical, and colorectal cancer screening: a systematic review. *Am. J. Prev. Med.* 35, S34–S55. doi: 10.1016/j.amepre.2008.04.002
- Carducci, A., Fiore, M., Azara, A., Bonaccorsi, G., Bortoletto, M., Caggiano, G., et al. (2021). Pro-environmental behaviors: determinants and obstacles among Italian university students. *Int. J. Environ. Res. Public Health* 18:3306. doi: 10.3390/ijerph18063306
- Clabeaux, R., Carbajales-Dale, M., Ladner, D., and Walker, T. (2020). Assessing the carbon footprint of a university campus using a life cycle assessment approach. *J. Clean. Prod.* 273:122600. doi: 10.1016/j.jclepro.2020.122600
- Cotton, D., Miller, W., Winter, J., Bailey, I., and Sterling, S. (2016). Knowledge, agency and collective action as barriers to energy-saving behaviour. *Local Environ.* 21, 883–897. doi: 10.1080/13549839.2015.1038986
- de Leeuw, A., Valois, P., Ajzen, I., and Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: implications for educational interventions. *J. Environ. Psychol.* 42, 128–138. doi: 10.1016/j.jenvp.2015.03.005
- de Vreede, C., Warner, A., and Pitter, R. (2014). Facilitating youth to take sustainability actions: the potential of peer education. *J. Environ. Educ.* 45, 37–56. doi: 10.1080/00958964.2013.805710
- Elias, T., Blaine, M., Morrison, D., and Harris, B. (2019). Media use, cross-national samples, and the theory of planned behavior: implications for climate change advocacy intentions. *Int. J. Commun.* 13, 3697–3718.
- Fortmann, S. P., Haskell, W. L., Williams, P. T., Varady, A. N., Hulley, S. B., and Farquhar, J. W. (1986). Community surveillance of cardiovascular diseases in the Stanford Five-City project. Methods and initial experience. *Am. J. Epidemiol.* 123, 656–669. doi: 10.1093/oxfordjournals.aje.a114285
- Gonzalez-Ramirez, J., Mulqueen, K., Zealand, R., Silverstein, S., Reina, C., BuShell, S., et al. (2021). Emergency online learning: college Students' perceptions during the COVID-19 pandemic. *Coll. Stud. J.* 55, 29–46. doi: 10.2139/ssrn.3831526
- Grantham, J. L., Verishagen, C. L., Whiting, S. J., Henry, C. J., and Lieffers, J. R. (2021). Evaluation of a social media campaign in Saskatchewan to promote healthy eating during the COVID-19 pandemic: social media analysis and qualitative interview study. *J. Med. Internet Res.* 23:e27448. doi: 10.2196/27448
- Greaves, M., Zibarras, L. D., and Stride, C. (2013). Using the theory of planned behavior to explore environmental behavioral intentions in the workplace. *J. Environ. Psychol.* 34, 109–120. doi: 10.1016/j.jenvp.2013.02.003
- Han, H., Hsu, L. T. J., and Sheu, C. (2010). Application of the theory of planned behavior to green hotel choice: testing the effect of environmental friendly activities. *Tour. Manag.* 31, 325–334. doi: 10.1016/j.tourman.2009.03.013
- Heath, Y., and Gifford, R. (2002). Extending the theory of planned behavior: predicting the use of public transportation. *J. Appl. Soc. Psychol.* 32, 2154–2189. doi: 10.1111/j.1559-1816.2002.tb02068.x
- Intergovernmental Panel on Climate Change. (2014). Climate change 2014 mitigation of climate change. Available at: https://archive.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf
- Intergovernmental Panel on Climate Change. (2019). Special Report: global warming of 1.5°C -summary for policymakers. Available at: <https://www.ipcc.ch/sr15/>
- Intergovernmental Panel on Climate Change. (2020). Special report: climate change and land-summary for policymakers. Available at: <https://www.ipcc.ch/srcccl/chapter/summary-for-policymakers/>
- Intergovernmental Panel on Climate Change. (2021). Climate change 2021: the physical science basis. Contribution of Working Group I to the sixth assessment report of the intergovernmental panel on climate change. Available at: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf
- Jamelske, E., Barrett, J., and Boulter, J. (2013). Comparing climate change awareness, perceptions, and beliefs of college students in the United States and China. *J. Environ. Stud. Sci.* 3, 269–278. doi: 10.1007/s13412-013-0144-x
- Kim, Y., and Kim, J. H. (2020). Using photos for public health communication: a computational analysis of the Centers for Disease Control and Prevention Instagram photos and public responses. *Health Informatics J.* 26, 2159–2180. doi: 10.1177/1460458219896673
- Kousar, S., Afzal, M., Ahmed, F., and Bojanc, S. (2022). Environmental awareness and air quality: the mediating role of environmental protective behaviors. *Sustain. For.* 14:3138. doi: 10.3390/su14063138
- Landholm, D. M., Holsten, A., Martellozzo, F., Reusser, D. E., and Kropp, J. P. (2019). Climate change mitigation potential of community-based initiatives in Europe. *Reg. Environ. Chang.* 19, 927–938. doi: 10.1007/s10113-018-1428-1
- Lederer, A. M., Hoban, M. T., Lipson, S. K., Zhou, S., and Eisenberg, D. (2021). More than inconvenienced: the unique needs of U.S. college students during the COVID-19 pandemic. *Health Educ. Behav.* 48, 14–19. doi: 10.1177/1090198120969372
- Leombruni, L. V. (2015). How you talk about climate change matters: a communication network perspective on epistemic skepticism and belief strength. *Glob. Environ. Chang.* 35, 148–161. doi: 10.1016/j.gloenvcha.2015.08.006
- Li, S. S. (2014). Fear appeals and college students' attitudes and behavioral intentions toward global warming. *J. Environ. Educ.* 45, 243–257. doi: 10.1080/00958964.2014.930399
- Li, X., Liu, Z., and Wuyun, T. (2022). Environmental value and pro-environmental behavior among young adults: the mediating role of risk perception and moral anger. *Front. Psychol.* 13:771421. doi: 10.3389/fpsyg.2022.771421
- Lin, S. P. (2013). The gap between global issues and personal behaviors: pro-environmental behaviors of citizens toward climate change in Kaohsiung, Taiwan. *Mitig. Adapt. Strateg. Glob. Chang.* 18, 773–783. doi: 10.1007/s11027-012-9387-1
- Mazo, K. R. F., and San Juan, F. M. (2019). Climate change consciousness among university students: implications to global education. *Asia Pac. J. Multidiscip. Res.* 7, 75–80.
- Murray, E. G., and DiGiorgio, A. L. (2021). Will individual actions do the trick? Comparing climate change mitigation through geoeengineering versus reduced vehicle emissions. *Earth's Future* 9:1734. doi: 10.1029/2020EF001734
- Namkoong, K., Nah, S., Record, R. A., and Van Stee, S. K. (2017). Communication, reasoning, and planned behaviors: unveiling the effect of interactive communication in an anti-smoking social media campaign. *Health Commun.* 32, 41–50. doi: 10.1080/10410236.2015.1099501
- National Cancer Institute. (2008). The role of the media in promoting and reducing tobacco use. Available at: https://cancercontrol.cancer.gov/sites/default/files/2020-06/m19_complete_0.pdf
- Noar, S. M. (2007). A 10-year retrospective of research in health mass media campaigns: where do we go from here? *J. Health Commun.* 11, 21–42. doi: 10.1080/10810730500461059
- Norman, P., Cameron, D., Epton, T., Webb, T. L., Harris, P. R., Millings, A., et al. (2018). A randomized controlled trial of a brief online intervention to reduce alcohol consumption in new university students: combining self-affirmation, theory of planned behaviour messages, and implementation intentions. *Br. J. Health Psychol.* 23, 108–127. doi: 10.1111/bjhp.12277
- Parrott, M. W., Tennant, L. K., Olejnik, S., and Poudevigne, M. S. (2008). Theory of planned behavior: implications for an email-based physical activity intervention. *Psychol. Sport Exerc.* 9, 511–526. doi: 10.1016/j.psychsport.2007.07.002
- Pew Research Center. (2021). Social media use in 2021. Available at: <https://www.pewresearch.org/internet/2021/04/07/social-media-use-in-2021/#:~:text=When%20it%20comes%20to%20the,report%20using%20Pinterest%20or%20LinkedIn.&text=In%20fact%2C%20a%20majority%20of,say%20the%20same%20for%20TikTok>
- Pilgrim, K., and Bohnet-Joschko, S. (2019). Selling health and happiness how influencers communicate on Instagram about dieting and exercise: mixed methods research. *BMC Public Health* 19:1054. doi: 10.1186/s12889-019-7387-8
- Pop, R.-A., Săplăcan, Z., and Alt, M.-A. (2020). Social media Goes green—the impact of social media on green cosmetics purchase motivation and intention. *Information* 11:447. doi: 10.3390/info11090447
- Prochaska, J. O., and Velicer, W. F. (1997). The transtheoretical model of health behavior change. *Am. J. Health Promot.* 12, 38–48. doi: 10.4278/0890-1171-12.1.38
- Record, R. A., Helme, D., Savage, M. W., and Harrington, N. G. (2017). Let's clear the air: a campaign that effectively increased compliance with a university's tobacco-free policy. *J. Appl. Commun. Res.* 45, 79–95. doi: 10.1080/00909882.2016.1248471
- Robelia, B. A., Greenhow, C., and Burton, L. (2011). Environmental learning in online social networks: adopting environmentally responsible behaviors. *Environ. Educ. Res.* 17, 553–575. doi: 10.1080/13504622.2011.565118
- Santarossa, S., and Woodruff, S. J. (2018). #LancetHealth: using twitter and Instagram as a tool in a campus wide health promotion initiative. *J. Public Health Res.* 7:1. doi: 10.4081/jphr.2018.1166
- Segerberg, A. (2017). Online and social media campaigns for climate change engagement. Oxford: Oxford University Press.
- Senbel, M., Ngo, V. D., and Blair, E. (2014). Social mobilization of climate change: university students conserving energy through multiple pathways for peer engagement. *J. Environ. Psychol.* 38, 84–93. doi: 10.1016/j.jenvp.2014.01.001
- Sinatra, G. M., Kardash, C. M., Taasobshirazi, G., and Lombardi, D. (2012). Promoting attitude change and expressed willingness to take action toward climate change in college students. *Instr. Sci.* 40, 1–17. doi: 10.1007/s11251-011-9166-5
- Sippel, M., Meyer, D., and Scholliers, N. (2018). What about greenhouse gas emissions from students? An analysis of lifestyle and carbon footprints at the University of Applied Science in Konstanz, Germany. *Carbon Manag.* 9, 201–211. doi: 10.1080/17583004.2018.1440851
- Song, Y., Bao, H., and Shen, S. (2022). Understanding the influence of initial values of college students in shaping pro-environmental behavioral intention. *Int. J. Environ. Res. Public Health* 19:9730. doi: 10.3390/ijerph19159730
- Steinmetz, H., Knappstein, M., Ajzen, I., Schmidt, P., and Kabst, R. (2016). How effective are behavior change interventions based on the theory of planned

behavior?: a three-level meta-analysis. *Z. Psychol.* 224, 216–233. doi: 10.1027/2151-2604/a000255

Tikir, A., and Lehmann, B. (2011). Climate change, theory of planned behavior and values: a structural equation model with mediation analysis. *Clim. Chang.* 104, 389–402. doi: 10.1007/s10584-010-9937-z

Wachholz, S., Artz, N., and Chene, D. (2014). Warming to the idea: university students' knowledge and attitudes about climate change. *Int. J. Sustain. High. Educ.* 15, 128–141. doi: 10.1108/IJSHE-03-2012-0025

Wakefield, M. A., Loken, B., and Hornik, R. C. (2010). Use of mass media campaigns to change health behaviour. *Lancet* 376, 1261–1271. doi: 10.1016/S0140-6736(10)60809-4

Webb, T. L., and Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychol. Bull.* 132, 249–268. doi: 10.1037/0033-2909.132.2.249

Wnuk, A., Oleksy, T., and Maison, D. (2020). The acceptance of Covid-19 tracking technologies: the role of perceived threat, lack of control, and ideological beliefs. *PLoS One* 15:e0238973. doi: 10.1371/journal.pone.0238973

World Health Organization. (2020). Climate change and human health-risks and responses. Available at: <https://www.who.int/globalchange/summary/en/index5.html>

Yusliza, M. Y., Amirudin, A., Rahadi, R. A., Athirah, N. A. N. S., Ramayah, T., Muhammad, Z., et al. (2020). An investigation of pro-environmental behaviour and sustainable development in Malaysia. *Sustain. For.* 12:7083. doi: 10.3390/su12177083

Yusoff, S., Bakar, A. A., Fakri, M. F. R., and Ahmad, A. Z. (2021). Sustainability initiative for a Malaysian university campus: living laboratories and the reduction of greenhouse gas emissions. *Environ. Dev. Sustain.* 23, 14046–14067. doi: 10.1007/s10668-021-01250-1



OPEN ACCESS

EDITED BY

Paolo Bertoldi,
European Commission Joint Research Centre
(JRC), Italy

REVIEWED BY

Georgios Pardalis,
Lund University, Sweden
Cunyi Yang,
Sun Yat-sen University, China

*CORRESPONDENCE

Christian A. Klöckner
✉ christian.klockner@ntnu.no

RECEIVED 03 January 2024

ACCEPTED 18 July 2024

PUBLISHED 06 August 2024

CITATION

Klöckner CA, Nayum A and Vesely S (2024)
Understanding users of online energy
efficiency counseling: comparison
to representative samples in Norway.
Front. Psychol. 15:1364980.
doi: 10.3389/fpsyg.2024.1364980

COPYRIGHT

© 2024 Klöckner, Nayum and Vesely. This is
an open-access article distributed under the
terms of the [Creative Commons Attribution
License \(CC BY\)](#). The use, distribution or
reproduction in other forums is permitted,
provided the original author(s) and the
copyright owner(s) are credited and that the
original publication in this journal is cited, in
accordance with accepted academic
practice. No use, distribution or reproduction
is permitted which does not comply with
these terms.

Understanding users of online energy efficiency counseling: comparison to representative samples in Norway

Christian A. Klöckner^{1*}, Alim Nayum² and Stepan Vesely¹

¹Department of Psychology, Norwegian University of Science and Technology, Trondheim, Norway,

²Department of Psychology, University of Bergen, Bergen, Norway

Introduction: To achieve substantial energy efficiency improvements in the privately owned building stock, it is important to communicate with potential renovators at the right point in time and provide them with targeted information to strengthen their renovation ambitions. The European Union recommends using one-stop-shops (OSSs), which provide information and support throughout the whole process, from planning to acquisition of funding, implementation, and evaluation as a measure to remove unnecessary barriers.

Methods: For this paper, we invited visitors of two Norwegian websites with OSS characteristics to answer an online survey about their renovation plans and energy efficiency ambitions. The participants visited the websites out of their own interest; no recruitment for the websites was conducted as part of the study ($N = 437$). They also rated a range of psychological drivers, facilitators, and barriers to including energy upgrades in a renovation project. Their answers were then compared to existing data from representative samples of Norwegian households regarding home renovation in 2014, 2018, and 2023, as well as data from a sample of people who were engaged in renovation projects in 2014, which was collected by the research team with a similar online survey. Furthermore, 78 visitors completed a brief follow-up online survey one year later to report the implemented measures.

Results: We found that visitors of the websites are involved in more comprehensive renovation projects and have substantially higher ambitions for the upgrade of energy efficiency compared to the representative samples. They also perceive stronger personal and social norms, as well as have a different profile of facilitators and barriers.

Discussion: The findings suggest to policymakers that OSSs should be marketed especially to people motivated to upgrade energy efficiency but lack information and are unable to implement their plans alone. Also, the construction industry might refer interested people to such low-threshold online solutions to assist informed and more ambitious decisions.

KEYWORDS

energy efficiency, renovation, one-stop-shops, counseling, psychological drivers, theory of planned behaviour, personal norms, facilitators

1 Introduction

Reducing energy use in the building sector by increasing energy efficiency is a key pillar of decarbonising Europe as formulated in the EU's "Fit for 55" legislation (Schlacke et al., 2022, 4). On a global level, the residential sector is the third largest energy consumer, representing 27–30% of the energy consumption, almost at the same level as transportation and industry (Nejat et al., 2015, 843; IEA, 2023). Also in Europe, the residential sector stands for 26% of final energy consumption, being the second largest consumption sector after transportation (Tsemekidi et al., 2019, 1). Whereas the primary energy consumption in the residential sector decreased by 4.6% between 2000 and 2016 (Tsemekidi et al., 2019, 9), there is still a substantial untapped potential for further improvement of energy efficiency in the sector. This can be achieved through energy efficiency renovation of the existing building stock (Pohoryles et al., 2020, 11–12). Realizing this potential requires that also private house owners invest in energy efficiency measures. However, the annual rate of housing renovation in Europe is only about 1% (Biere-Arenas and Marmolejo-Duarte, 2022, 185), which is far too slow to reach the ambitious energy conservation targets. Besides, not all of those renovations include energy efficiency improvements. This raises the question of how property owners make decisions about renovating and energy efficiency measures and how they can be efficiently supported in these processes. To alleviate this problem, one-stop-shops (OSS), which are places where interested citizens can get counseling and support for the whole process of an energy retrofit, have gained a lot of attention lately as a means to support citizens in the matter of energy retrofits also from the European Union (as for example reflected in recently finished EU projects like "EUROPE one stop" or "ProRetro").

1.1 One-stop-shops in energy counseling

Bertoldi et al. (2021, 3–12) analysed the role of OSSs across Europe. They concluded that OSSs may be able to address some of the main barriers that households face when deciding about energy efficiency renovations. Often, these barriers can be categorized as economic (upfront costs, need for loan, split incentives between landlords and renters/disagreement between owners), information (information asymmetries, outcome uncertainties, incorrect beliefs), and decision-making (limited attention, social invisibility of the action, cognitive burden, loss aversion, status quo bias). Their analysis of 63 OSSs over Europe showed that the services the OSSs offer differ considerably, as do their business models. Some of them are public entities that often offer services for free, others are commercial enterprises. Their clients are usually homeowners living in relatively old buildings, and only a few of them work with social housing. Also Bagaini et al. (2022, 3–4) analysed and categorized 29 OSS initiative around Europe and formulated five key elements on which the different OSS differed: (a) value proposition, (b) services, (c) partnership management, (d) revenue stream, and (e) shared value. Based on these dimensions, they distilled three archetypes for OSS models: They refer to them as the Facilitation Model (mostly focused on providing information to homeowners without a revenue generation model behind), the Coordination Model (also taking in a project management role

with the contractors and generating revenue by fixed fees), and the Development Model (similar to the Coordination Model but with a revenue generated dynamically from the shared energy savings). Along similar lines, Pardalis et al. (2022) compared publicly and privately funded OSSs. In addition to the facilitation and the coordination model they separate the development model into "all inclusive models" (where the renovation process is fully managed by the OSS under one single contract, but energy savings are not guaranteed) and "ESCO models" (where Energy Service Companies—ESCOs—manage the whole renovation package and also guarantee energy savings). Whereas publicly funded OSSs are evaluated as providing homeowners with crucial services at the right time, privately funded OSSs struggle more with generating revenue and providing access to financing.

According to Bertoldi et al. (2021), a key activity all of the surveyed OSSs cover is the assessment of the status quo, which is done in different ways (sometimes as a guided online self-assessment). Then, a stage of guidance toward possible measures is started, usually resulting in an individual renovation plan. In the next stage, financing is secured (either directly or indirectly, for example by supporting applications for subsidies). In the implementation stage, OSSs either manage the implementation themselves or recommend contractors who will do that. Often OSSs are involved in quality assurance of the implemented measures afterwards, sometimes certifying the result. Some OSSs also monitor the building after the energy upgrade to support the clients, often through a contract where financial benefits are shared between the OSS and the client (often in ESCO models). Finally, most OSSs also engage in campaigns for energy efficiency in buildings to increase awareness.

McGinley et al. (2020, 355–57) formulate some key considerations for OSS design. They define OSS as offering full-service retrofitting, including initial building evaluation and thorough analysis, proposal of retrofitting solutions, retrofit execution, and quality assurance. However, they also state that little is known about characteristics and motivations of households that are drawn to OSS and how household decisions are impacted by OSSs, a research gap we aim to fill with this paper.

A number of recent EU projects have addressed the issue of OSSs in detail. In particular, the "EUROPA one stop" project (europaonestop.eu) is interesting as it created an online platform (SUNShINE—savehomesave.eu) to connect homeowners, facility managers, and contractors working on energy efficiency upgrades and provide them with easy access tools to online diagnose their renovation potential. This platform is structurally comparable with the platforms analysed in this paper and can be considered a concept following the facilitation model. However, to understand how homeowners may be affected by OSSs, it is important to take a look at decision-making processes.

1.2 Psychological drivers of implementing energy efficiency in renovation of privately owned dwellings

In a detailed study of decision-making about energy retrofits in Norwegian households data of which was also used as a comparison for this study, Klößner and Nayum (2017, 1014) found that

an extended Theory of Planned Behaviour (Ajzen, 1991, 182; Klößner, 2013, 1032) formed a viable theoretical framework to structure these decision processes. They were able to show that personal norms, positive attitudes, and high self-efficacy were the decisive factors for forming intentions to include energy efficiency upgrades in renovation projects. Social norms were closely related to personal norms and an important trigger of these. More distal factors were problem awareness, value orientations, perceived consumer effectiveness, and innovativeness. The most central concepts are briefly introduced in the next paragraph.

In this context, personal norms are a feeling of moral obligation to invest in better energy efficiency. Positive attitudes are the overall evaluation of the pros and cons of the decision to invest. That is how good or bad this would be, all taken into account. Self-efficacy captures how capable one feels to implement the investment, a factor that most likely will be directly affected by engaging with an OSS. Following the theoretical framework as outlined and tested by Klößner and Nayum (2017, 1014), an intention to invest will thus be formed: (a) if people feel that they are morally obliged to do that because wasting energy is a bad thing which is more likely; (b) if other people who are important to them support this view. Furthermore, c) a positive attitude to energy efficiency investments d) and a high self-efficacy (i.e., knowing how to implement these measures and/or who to contract to do it) also contribute. As attitudes are a combination of positive and negative beliefs about the behavioral alternatives that people choose between (Ajzen, 1996, 385–403), a closer look at assumed barriers and facilitators underlying those alternatives could help in understanding the decision process further, as discussed in the next section.

1.3 Barriers and facilitators of energy efficiency measures in buildings

A number of studies analyzed facilitators of or barriers against implementing energy efficiency in a residential building from different theoretical and methodological perspectives. In his PhD thesis, Pardalis (2021, 60) finds, based on an online survey with almost 1000 homeowners in Sweden, that the house age and time lived in a house but also energy concern trigger the decision to renovate. These factors are, again, influenced by sociodemographic factors of the occupants. Thus, structural aspects seem of importance as drivers of the retrofit decision.

Digging deeper into the decision process, Xue et al. (2022, 5) conducted interviews with 39 professionals in the retrofit market to identify barriers to energy retrofitting from the perspective of the public sector, the private sector, and the owners who conduct the retrofit. They found financial issues as the most important barrier in all three groups. For owners who are supposed to implement energy efficiency measures, they further named lack of information, lack of creative models or cases, risks connected to the project, trust, and negative social influence as important barriers. Also, problems of reaching an agreement, time consuming processes, limited added value, and concerns about payback time were named.

Many of these aspects were also reflected in another qualitative study. Klößner et al. (2013, 406–408) interviewed 70 Norwegians on drivers and barriers regarding energy efficiency behaviour. They found that economic barriers (e.g., lack of investment

money), motivational barriers (e.g., too much effort, loss of comfort, low perceived efficacy), structural barriers (e.g., building structure, ownership), and informational barriers (e.g., lack of trust, uncertainty, lack of specific information) were central.

Departing from practice theory in an ethnographic study of renovation projects, Judson and Maller (2014) interviewed 49 Australians involved in renovation projects and unraveled the process of renovation even more. They found that renovation projects, to a large degree, are shaped and reshaped by the existing or evolving practices people have within their buildings. Energy efficiency is traded off against other needs and meanings, negotiation between different household members occur, and focus shifts dynamically. Some parts of the home have a meaning for its inhabitants as part of their daily practices which cannot just be changed to enhance energy efficiency.

With a quantitative perspective, Klößner and Nayum (2016, 5) studied barriers in different stages of renovation processes in a representative sample of Norwegian households. Their findings indicate that facilitators like perceived increase in comfort, anticipated better living conditions or increased marked value were important in the early stages of decision making. Information about subsidy schemes or trustworthy information about the procedures came out as important at a later stage when planning was more advanced. Correspondingly, some barriers like building protection regulations, planning to move soon, or not owning the building were relevant already early in the process before people started even thinking about an energy retrofit, whereas barriers like too much disturbance of everyday life, contractors with a lack of competence, the need to supervise contractors, or a lack of economic resources were turned out to be relevant barriers later in the process. A particularly important barrier appeared to be the feeling that “the right point in time for a larger renovation project has not come, yet”.

In an economic modeling approach comparing expected utility theory (which assumes that decision makers chose the alternative with the best possible utility for them) and cumulative prospect theory (which assumes that decisions about investments are strongly affected by specific decision biases), Ebrahimigharehbaghi et al. (2022) found that cumulative prospect theory, which takes biases like “reference dependence” (utility changes are interpreted differently with respect to difference reference points), “loss aversion” (losses weigh higher than gains of the same size), “diminishing sensitivity” (avoiding risk for positive outcomes but taking risks for negative outcomes), and “probability weighting” (events with low probability but more extreme outcomes are overestimated) is much better equipped to predict homeowners investments in home energy efficiency in a large sample from the Netherlands than classical expected utility theory. This shows that people’s decision-making in such cases takes other aspects than economic utility into consideration to a large degree.

Studies such as the ones briefly mentioned above show that the selection of aspects that can interfere with or facilitate a decision-making process about energy retrofits is plentiful. In addition, they even have different importance depending on where in the process a decision-maker is. This makes it demanding to provide the most helpful support for decision-makers in the residential sector. It seems important to provide the right information at the right time to the right people, which underscores the need for careful targeting and timing of information provision. Flexible and interactive online

counseling systems, which can take people through all stages of the process, similar OSSs, may be a way to find a good balance between resources needed and effects achieved in targeted energy counseling. Interestingly, [Pardalis \(2021, 66\)](#) asked homeowners what would be most important for them with respect to OSSs, and guarantees for costs and quality, as well as having one contact and one contract and a preliminary check and counseling were on top of the list, directly addressing some of the issues identified as barriers in many of the studies above.

1.4 The present study

Summarizing what has been outlined in the introduction, energy efficiency upgrades of residential buildings are a major contributor to reaching the targets of the energy transition of the European Union. However, the private residential sector is lagging behind in this process. Renovation rates of the aging building stock are low. Even when the buildings are renovated, energy efficiency measures are not always implemented. In cases where some energy efficiency measures are included, they are often not to the standard that would be recommendable. One-stop-shops have been heavily promoted recently as a way of removing the burden of planning, financing, and implementing a deep renovation project from the individual house owners. Consequently, many such services have been implemented around Europe with differing business models, financing, and mandate. However, relatively little is known about who uses these services and what effect they have on their users. Especially, it is unknown to a large degree how interacting with a low-threshold digital OSS following a facilitation model shapes its users' perception of barriers and facilitators of a retrofit decision, and if it affects their motivations and ambitions for this project. This research gap is addressed by the present study. More specifically, we are analysing if visitors of energy efficiency counseling websites differ in their engagement in retrofits, their energy efficiency ambitions, the profile of psychological variables, the drivers and barriers from representative samples of the population and a sample of home renovators.

Our study is, thus, contributing to the literature by providing new insights into how natural users of websites with OSS characteristics differ from the general population of homeowners on a number of psychological and socio-demographic characteristics. This helps on the one hand to identify who are the target group for such low-threshold website services, but on the other hand, we also provide an assessment if their renovation ambitions, and especially the level to which they intend to implement energy efficiency measures in these updates differs after they visited the service. Through a one-year follow-up, we can also provide an assessment of to which degree the planned measures were implemented. Taken together, the focus on primarily psychological drivers and barriers of energy efficiency investments in homes for a very specific target group in comparison to large, representative samples of homeowners paints a new, and informative picture of who the users of these websites are not only socio-demographically, but also psychologically, what they are looking for on these websites, and to which degree the websites support them in their pathway towards more energy efficient

homes. Being able to run the comparisons of a relatively large sample of website users to several, large representative comparison samples which were surveyed with the same methodology in the same country over the course of 10 years provides an unique opportunity to understand the target group.

2 Materials and Methods

2.1 Study design

For this study, we collected responses from users of two online energy efficiency counseling websites, which have a similar structure that might be conceptualized as OSS following a facilitating model. These websites offer an analysis of the current energy standard of privately owned residential buildings (either as a guided self-assessment or based on data from the Norwegian building registry). They can also suggest a rough renovation plan and connect the homeowner to potential contractors who can implement energy efficiency measures. Moreover, they can provide information about costs, pay-off rates, subsidies (incl. information on how to apply), etc. Energismart.no is promoted by the environmental organization Friends of the Earth Norway, whereas energiportalen.no is promoted by Viken county. From January 2022 until January 2023, participants for the study were recruited from natural visitors of both websites by messages on the websites and pop-up windows, which promoted participation in our study and provided a link to the online questionnaire. We thus recruited people who visited the websites out of their own interest without promoting using the websites from our end. This sampling strategy was chosen to recruit a ecologically valid group of website users.

In the online survey, participants were then asked about their plans for retrofitting their homes, recently finished or ongoing retrofitting projects, the ambitions for energy efficiency upgrades as part of these retrofits, and psychological drivers and barriers of the decisions.

Since randomization of users of the websites was not possible, as people self-assigned to the websites, we chose a comparison group design, where we compared the means and distributions of key variables in our survey against representative homeowner data collected in 2014, 2018, and 2023 ([Klößner and Nayum, 2016, 2017](#); [Egner and Klößner, 2021](#); [Egner et al., 2021](#); [Peng and Klößner, 2024](#)) with the same survey instrument (see [Table 1](#) for an overview of the survey samples). Because of that design, we are unable to draw causal conclusions, but we can get indications for differences between the samples (for a deeper discussion, see the limitations section below). We were also not able to survey our participants before they entered the websites. Thus, we do not know if the described differences were already there before they used the website, or which differences were caused by the website visit. It is likely that people visit such counseling websites when they already have developed an interest for the information presented there. Thus, some of the differences will have existed already pre-visit. Especially some of the drivers and barriers, but also some parts of the psychological profile might fall into that category and it is important to keep this in mind when interpreting the results. Furthermore, we do not know how long people stayed on the

TABLE 1 Overview of sample statistics in the different samples.

	Energy efficiency counseling website users	One year follow up website users	Representative sample of Norwegian households	Representative sample of Norwegian households	Representative sample of Norwegian households	Sample of Norwegian households in a renovation project
Year of data collection	2022–2023	2023	2014	2018	2023	2014
Source	Collected for this study	Collected for this study	Originally collected for Enova	Originally collected for Enova	Originally collected for the BEHAVIOR project	Originally collected for Enova
Number of participants	437	78	2,605	3,807	1,314	1,182
Gender						
Female	231 (52.9%)	27 (34.6%)	1,332 (51.1%)	1,858 (48.8%)	657 (50.0%)	543 (45.9%)
Male	199 (45.5%)	51 (65.4%)	1,273 (48.9%)	1,949 (51.2%)	656 (50.0%)	639 (54.1%)
Other	1 (0.2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Mean age (SD)	53.0 (12.6)	54.4 (13.5)	49.2 (15.7)	52.7 (16.5)	48.5 (17.2)	50.6 (15.1)
Highest education						
Basic education	14 (3.2%)	1 (1.3%)	214 (8.2%)	191 (5.0%)	60 (4.6%)	63 (5.3%)
Vocational school	48 (11.0%)	12 (15.4%)	977 (37.5%)	955 (25.1%)	321 (24.4%)	268 (22.7%)
College	34 (7.8%)	5 (6.4%)	658 (25.3%)	352 (9.2%)	149 (11.3%)	220 (18.6%)
University	339 (77.9%)	60 (76.9%)	756 (29.0%)	2,309 (60.6%)	783 (59.6%)	631 (53.4%)
Median gross household income						
NOK	800,000–999,999	1,000,000–1,199,999	600,000–799,000	800,000–999,999	Individual gross income: 500,000–599,999	800,000–999,999
EURO	70,400–88,000	88,000–105,600	52,800–70,400	70,400–88,000	44,000–52,800	70,400–88,000
Type of house						
Detached house	293 (67.2%)	56 (71.8%)	1,436 (55.1%)	1,997 (52.7%)	625 (47.6%)	765 (64.7%)
Duplex	51 (11.7%)	13 (16.7%)	163 (6.3%)	252 (6.6%)	83 (6.3%)	88 (7.4%)
Terraced house	45 (10.3%)	5 (6.4%)	342 (13.1%)	480 (12.7%)	140 (10.7%)	136 (11.5%)
Apartment building	35 (8.0%)	2 (2.6%)	505 (19.4%)	869 (22.9%)	367 (27.9%)	157 (13.3%)
other	12 (2.8%)	2 (2.6%)	159 (6.1%)	194 (5.1%)	98 (7.4%)	36 (3.1%)
Ownership						
Owning	418 (96.6%)	75 (96.2%)	2,198 (84.4%)	3,344 (88.1%)	1,113 (84.7%)	1,100 (93.0%)
Renting	15 (3.5%)	3 (3.8%)	407 (15.6%)	451 (11.9%)	194 (14.8%)	82 (6.9%)

websites, what they read, and how much they used the information to adapt their renovation strategy, which would have given us more insights into their user experience. However, we believe that comparing the visitors to representative homeowners from different historical points in time in the same country surveyed with the same questionnaire can give us some relevant insights and at least input for generating new hypotheses.

Differences between the samples were identified by comparing 95% confidence intervals for the means. Non-overlapping confidence intervals were interpreted as significant mean differences. Effect sizes for the differences are presented in [Supplementary Appendix Table 1](#).

One year after the participants answered the survey, we approached them again with a short survey asking if and which retrofitting measures had been implemented in the meantime and

if not, why. The follow-up survey was sent to every participant who agreed to be contacted again.

2.2 Survey

The surveys conducted in all different studies compared here were collected through an online survey platform operated by the University of Oslo (Nettskjema.no). The questions used for the analyses presented in this paper composed only part of the questionnaires; we describe only the relevant questions below. The full survey can be found in the data repository together with the dataset.¹

¹ <https://zenodo.org/records/12605729>

2.2.1 Sociodemographic information

In the surveys, participants were asked about their gender, age, highest education level, gross household income (in the 2023 data collection, individual gross income was recorded), the type of house they lived in, and if they owned or rented their dwellings. The categories of these variables can be found in [Table 1](#).

2.2.2 Deep renovation

To capture if the participants were just finished, engaged in, or planning what we refer to as a “deep renovation” project, we asked them the following questions:

- (1) Within the previous three years, were you involved in a renovation project that involved (a) substantial work on the roof like replacing all tiles, (b) replacing at least 50% of the outer walls, (c) replacing at least 50% of the window area, and/or (d) substantial work on the foundation? This definition was developed for the 2014 study in a collaboration of the researchers behind the studies and the Norwegian Energy Efficiency Agency Enova and used in the same form in all data collections since. The aim of this definition was to differentiate larger renovation projects from smaller, more cosmetic renovation projects.
- (2) Are you currently involved in a renovation project according to the definition above or are you planning to engage in such a renovation project within the next three years?

However, the definition does not automatically assume that energy efficiency measures are included in the deep renovation project.

The ambition level of these renovation projects was measured by how many of the four components they (are planning to) implement, and it ranges from 1 to 4.

2.2.3 Energy efficiency upgrade

If participants answered “yes” to either or both of the questions presented in the previous section, they were asked if that renovation project included, includes or is planned to include (a) additional insulation of the roof of at least 10 cm, (b) adding additional insulation to the walls of at least 5 cm, (c) energy saving windows with a μ -value of 1.0 or lower, (d) at least 5 cm additional insulation to the foundation walls, (e) installation of mechanical ventilation, and/or (f) installation of balanced ventilation. Also here, the definition of these measures was agreed upon with Enova in 2014 to represent a substantial improvement in the energy standard of the respective building component. For our analyses, we counted the number of these measures that had been/were planned to be implemented in the deep renovation project. The number could thus be between 0 and 6.

2.2.4 Personal norms, social norms, attitudes, and efficiency

Based on the Theory of Planned Behaviour ([Ajzen, 1991](#), 182) extended by personal norms from the Norm-Activation Model ([Schwartz and Howard, 1981](#)), four psychological variables are central to understand people’s intentions: attitudes, social norms, perceived behavioral control or behavioral efficacy, and personal norms. Each of these variables was measured by two items in the

surveys, with a 7-point Likert scale from -3 to $+3$. Higher values indicate stronger norms, attitudes, or efficacy.

The two items to measure social norms were “People who influence my decisions think I should insulate my home” and “People who are important to me think I should retrofit my home”. The two items to measure perceived efficacy were “I know which person or company I need to contact to have my home professionally insulated” and “I know what I need to do to insulate my home”. The two items to measure personal norms were “Because of my values/principles, I feel obliged to insulate my home” and “I feel personally obliged to retrofit my home”. For each pair of items, the mean score was calculated and used in subsequent analyses.

Attitudes were measured with four semantic differentials: “Increasing the energy standard of my home would be (a) useless—useful, (b) uncomfortable—comfortable, (c) unfavorable—favorable, and (d) bad—good”. Each pair has -3 as the anchor for the negative word and $+3$ as the anchor for the positive word. For further analyses, the mean of the four items was calculated.

All items had been used in an identical way since the first study in 2014, as documented elsewhere ([Klößner and Nayum, 2016, 2017](#)). In the 2023 data collection, different answering scales were used, therefore the results are not comparable and are not reported here ([Peng and Klößner, 2024](#)).

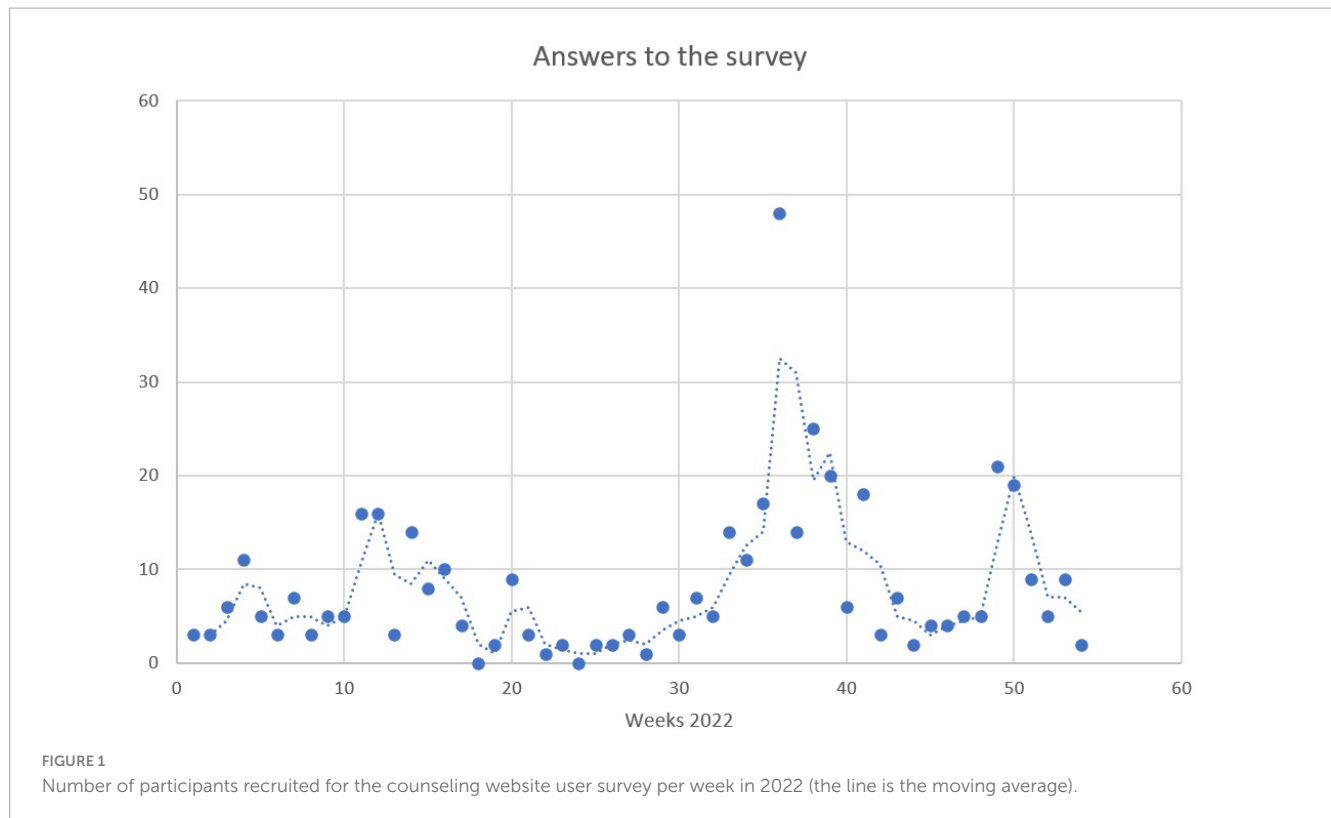
2.2.5 Barriers and facilitators

Finally, a list of potential barriers and facilitators of energy efficiency upgrades was presented in random order to the participants, asking how much they agreed with each item. The items can be found in the [Supplementary Appendix](#). These lists were derived from a qualitative study on reasons why Norwegians upgrade or decide not to upgrade energy standards of their dwellings ([Klößner et al., 2013](#)). In the 2023 data collection, different answering scales had been used, therefore the results are not comparable and are not reported here.

2.3 Sample and comparison groups

The sample of counseling website users was recruited from the first week of January 2022 to the first week of January 2023. In total, 437 answers were collected. These answers were not equally distributed over the year, however, as [\(Figure 1\)](#) shows. Whereas relatively many responses were collected in winter and early spring 2022, the interest was reduced in late spring and summer before it skyrocketed after summer 2022, as well as in winter 2023. This coincided with electricity price peaks in Norway (especially in the South) and media discussions about that topic. Thus, a first conclusion can already be that the interest in using energy efficiency counseling websites clearly follows the pattern of the energy price fluctuation and accompanying societal discussion.

[Table 1](#) below shows the sociodemographic statistics of the sample from the counseling websites in comparison to the existing samples in detail. As can be seen, the samples are comparable on most of the dimensions. All samples contain close to 50% males and females (with the most deviation in the sample of renovators from 2014). The average age is around 50 years in all samples, with the



youngest average age in the 2023 population sample and the oldest average age in the sample of the users of the websites. Education varies quite strongly, with the population sample from 2014 being the outlier with far lower education level than all other samples. Participants recruited from the counseling websites had the highest education level. The median household gross income category is the same in most samples. However, it is lower in the 2014 population sample and higher in the sample of people who answered the one-year follow-up after the visit on the counseling websites. Income categories of the 2023 sample cannot be compared, as individual gross income was recorded in that data collection. However, it can be extrapolated that the average household income would be comparable to the other samples. The proportion of people living in detached houses is particularly high in the sample of website users and the renovator sample from 2014. Also, the level of people owning their dwelling is close to 100% in these groups and a little lower in all other groups. As a conclusion, it can be said that the samples are comparable on most dimensions. Meanwhile, the website users are most similar to the people who were recruited as being in a renovation project in 2014. That is, they are more likely better educated, more likely to live in a detached house, and more likely to own their dwelling than representative samples of Norwegian households.

3 Results

In the following section, we present the results of the comparison of the counseling website users with the other available samples. To do this, we examine the 95% confidence intervals as displayed in the figures for overlaps between the group of website

users and the other groups. As the data is partly in separate datasets, we did not calculate formal significance tests, but a non-overlapping 95% confidence interval corresponds to an assumed significant difference between the respective groups. The numbers for the website users are always highlighted in the figures. Effect sizes are reported in [Supplementary Appendix Table 1](#). An overview of all results can be found in [Table 2](#).

3.1 Engagement in deep renovation

As can be seen in [Figure 2](#), the percentage of people who were involved in a deep renovation project is higher in the group of counseling website users than in all three population samples. The same can be said for the ongoing or planned deep renovation projects, which are also more common for people visiting the energy counseling websites. Only the group that was specifically recruited in 2014 to only contain respondents who either just had been, were still, and/or were planning a deep renovation project in the near future has higher numbers (which is not surprising). Interestingly, the number of finished and planned projects in the population sample is lower in 2023 than in 2018 and 2014, likely an effect of renovation saturation after COVID years.

Among the users of the energy counseling websites, the ambition level is higher than in any other group, both for finished, ongoing and planned projects (see [Figure 3](#)). This means that they are engaged in slightly larger projects, involving more of the four different potential measures (walls, windows, roof, foundation). Thus, these people probably are or plan to be involved in more comprehensive renovation projects.

TABLE 2 Summary of the differences between the website visitors and the representative homeowner samples from 2014, 2018, and 2023, as well as the renovator sample from 2014.

	2014	2018	2023	Renovators (2014)
Renovation conducted	+	0	+	—
Renovation ongoing/planned	0	0	+	—
Renovation levels conducted	+	—	+	+
Renovation levels ongoing/planned	++	++	++	++
EE levels conducted	++	++	+	++
EE levels ongoing/planned	+++	+++	++	+++
Attitudes	+	+		0
Personal norms	+++	+++		++
Social norms	++	++		+
Self-Efficacy	—	0		—
More comfort	+	+		0
Cost reduction	++	++		+
Better life	+	++		+
Information trust	0	0		+
Increased value	+	+		0
Health effects	0	+		0
Energy waste	++	++		+
Info easy to find	—	—		—
Subsidy	—	—		—
Short payback time	0	0		—
Much time	+	+		+
Lack of money	++	++		++
Disruption	+	0		+
Not right time	—	—		0
Lacking trust	0	0		0
Info difficult to find	++	++		+
Cannot decide	++	++		+
Builders lack knowledge	++	++		++
Moving out	+	0		+
Must agree with neighbours	0	0		0
Negative experience	0	+		0
Building protection	0	+		0
Renting	0			0

+, the website users score higher with a small effect size, ++, the website users score higher with a medium effect size, +++, the website users score higher with a large effect size, —, the website users score lower with a small effect size, —, the website users score lower with a medium effect size. For the exact effect sizes, please see [Supplementary Appendix Table 1](#).

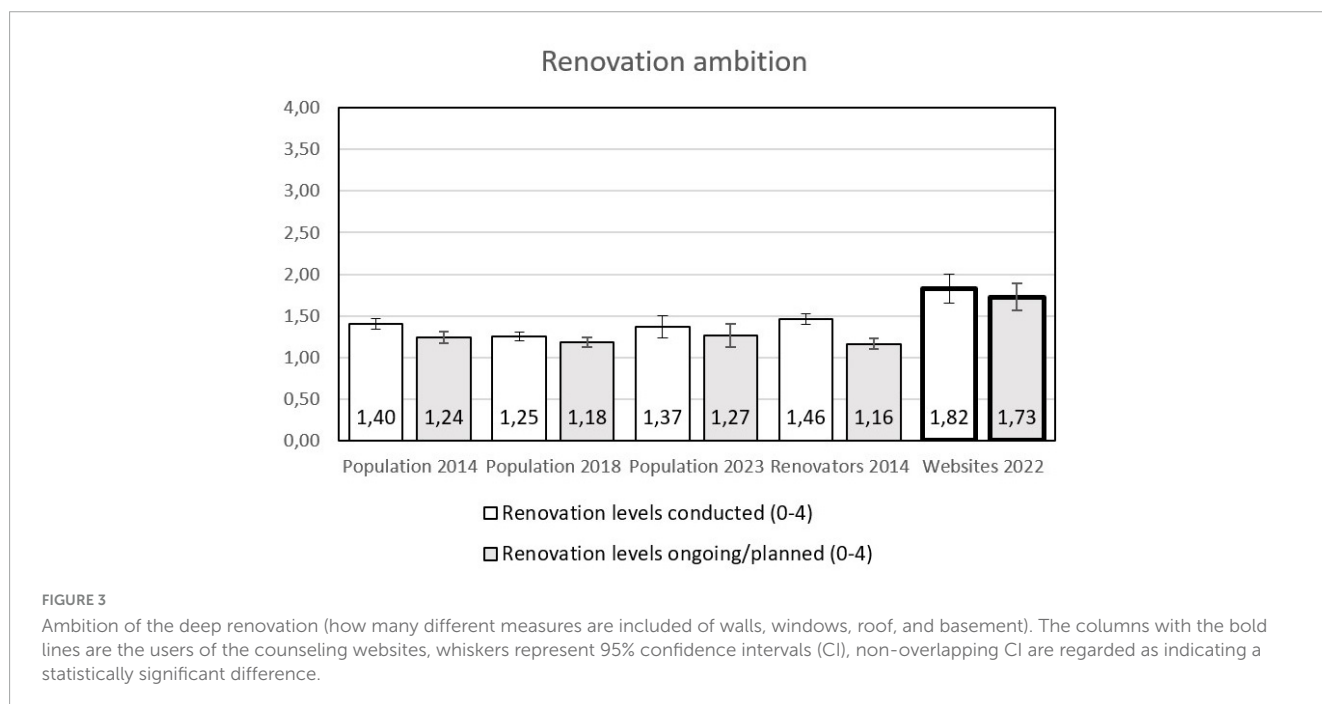
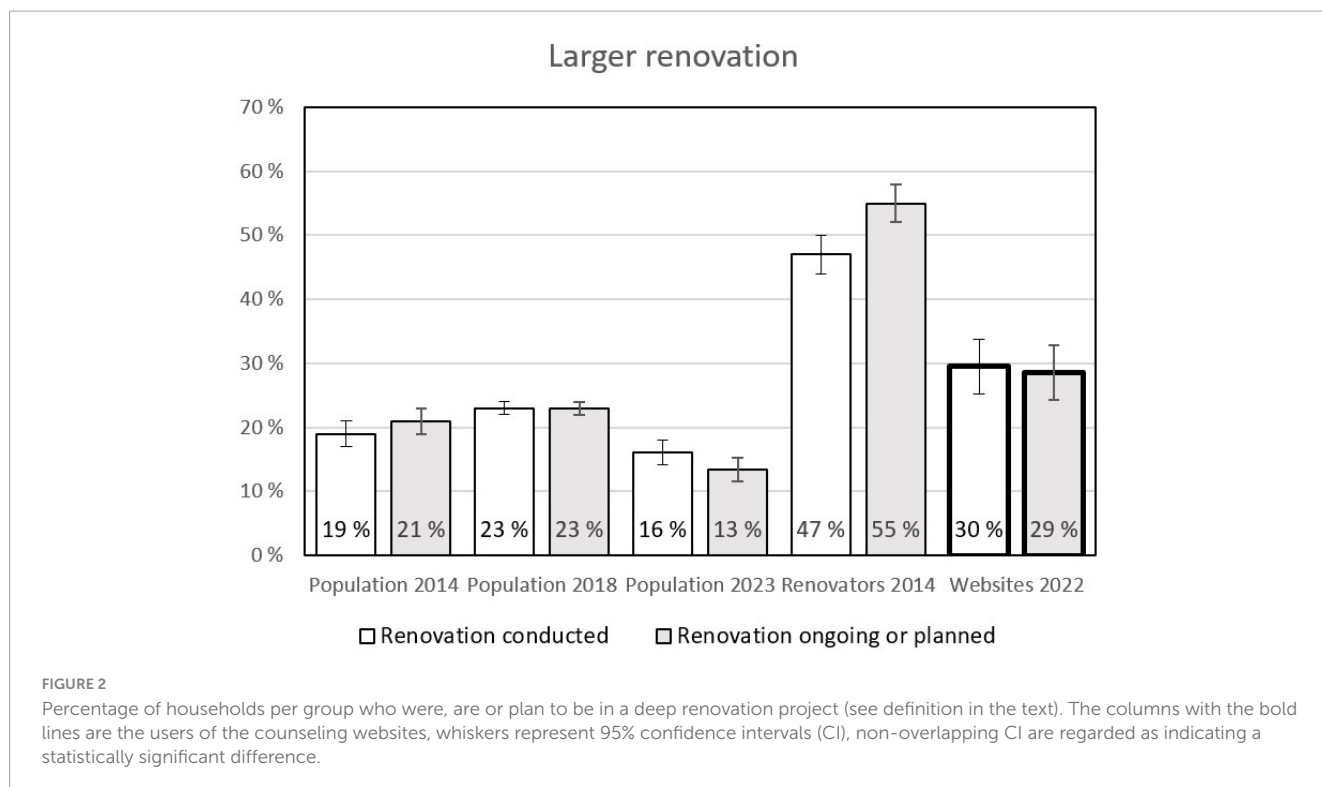
3.2 Energy efficiency ambitions

When looking at the level of ambitions for integrating energy efficiency upgrades in the renovation projects, the picture is even more interesting (see [Figure 4](#)). Among the users of the energy counseling websites, the ambition level is substantially higher than in any other group, both for finished, ongoing, and planned projects. On a side note, even if the total percentage of people involved in deep renovation was lower in the population in 2023 than in 2014 and 2018, the degree to which energy efficiency

measures are included is increasing as can be seen in [Figures 2, 4](#). This may be an effect of the energy crisis in Europe in 2022.

3.3 Psychological drivers

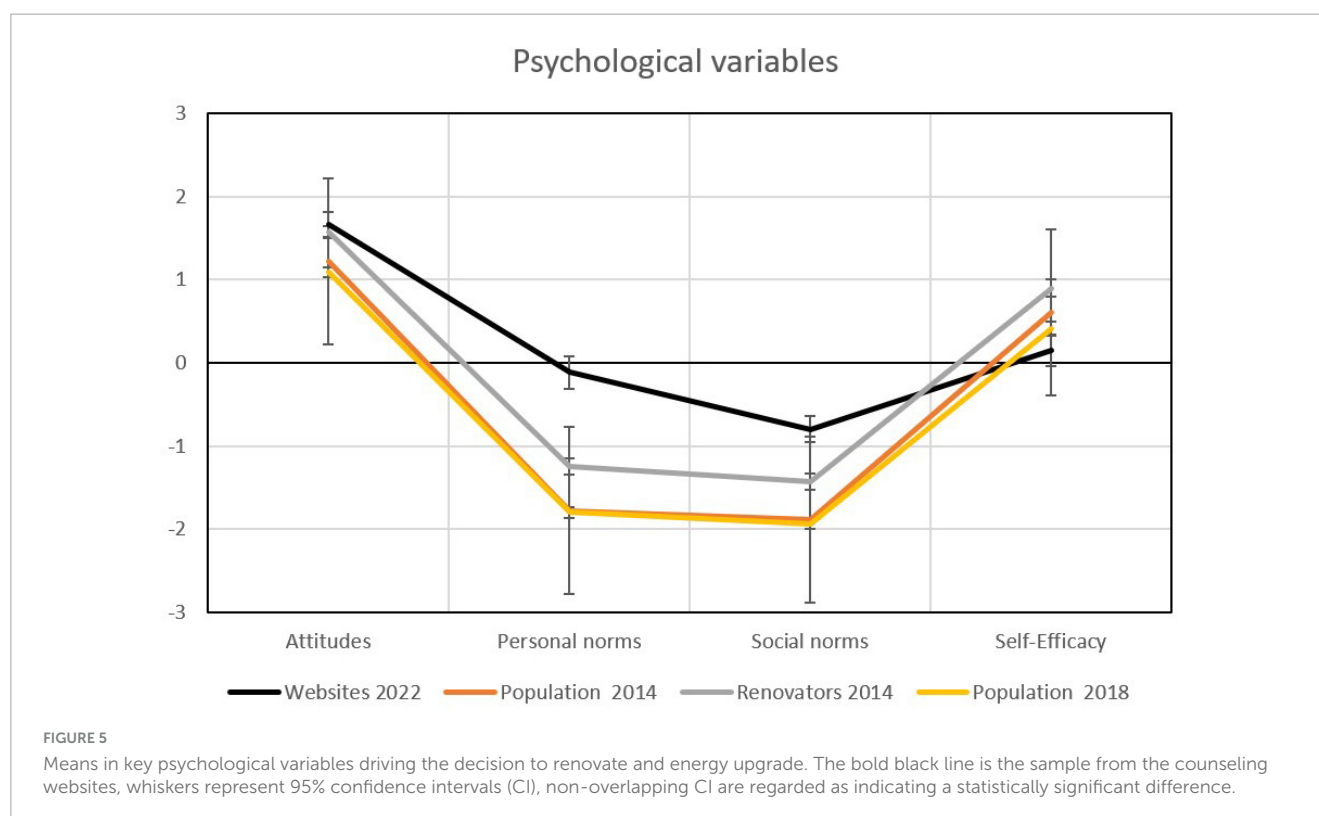
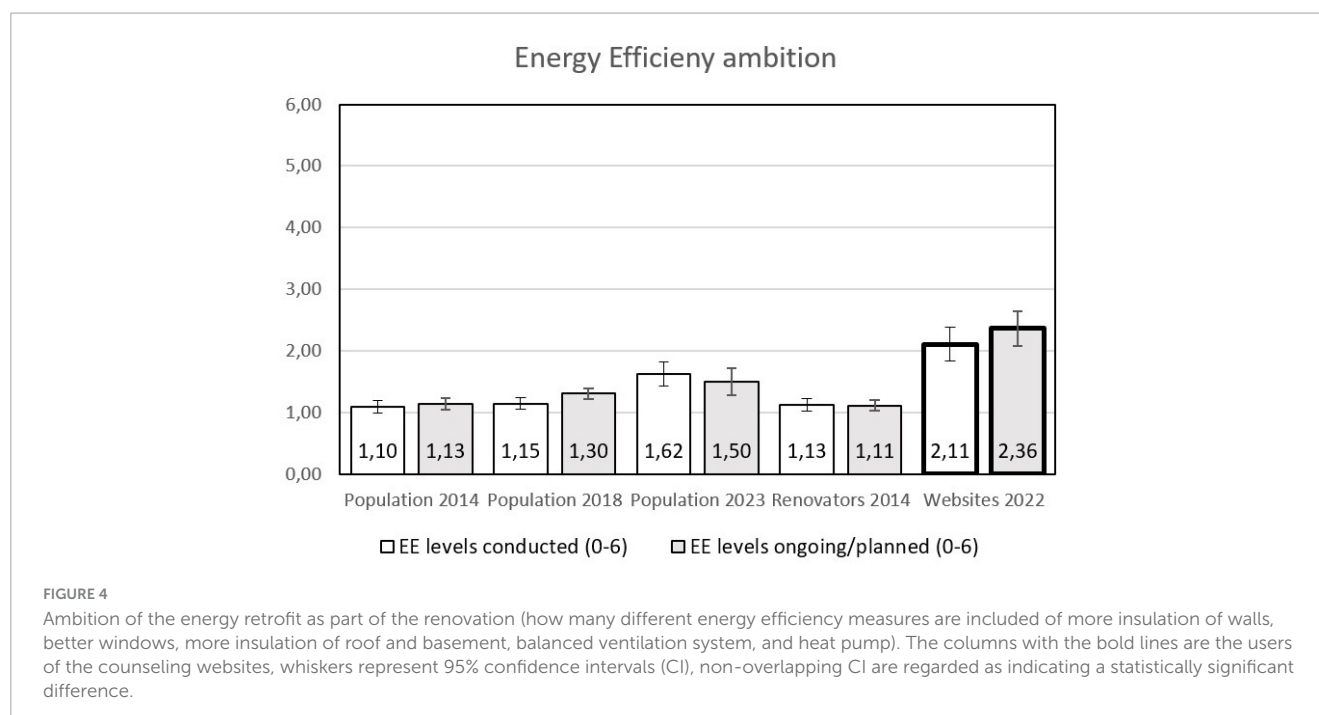
When comparing the psychological profiles of the website users to the population profiles from 2014 and 2018, it can be seen that the website users have substantially higher personal norms. This indicates that they feel more moral pressure to increase the energy



efficiency of their dwellings (see [Figure 5](#)). They also feel stronger social norms, meaning more social pressure from their peers to engage in such energy upgrades. For attitudes, the differences are smaller. Meanwhile, the attitudes are slightly more positive than for the population samples, on the same level as for the renovators in 2014. Interestingly, despite small differences, the website users have the lowest perceived self-efficacy, especially compared to the renovators in 2014. In contrast to renovators in 2014, they feel less convinced that they know how to go about for the renovations.

3.4 Facilitators and barriers of energy efficiency upgrades

[Figures 6, 7](#) show how the website users perceive facilitators and barriers of energy efficiency upgrades of their dwellings in comparison to people in the other samples. For some facilitators and barriers, differences are substantial: counseling website users expect more comfort, a cost reduction, a house that is better to live in, increased property value, and less waste of energy as a result

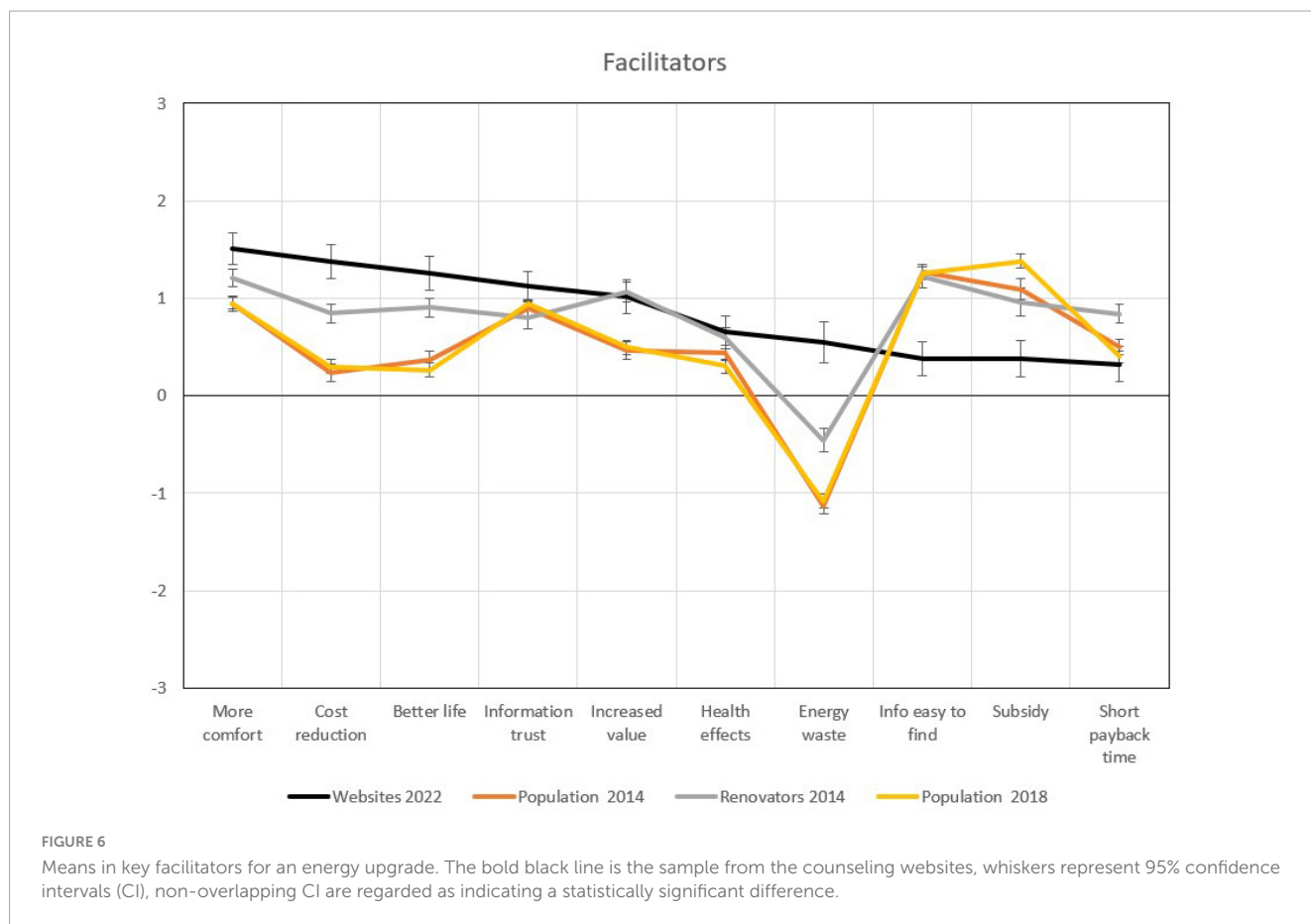


of the renovation. They score the lowest of all samples, though, on availability of information, payback time, and availability of subsidy.

For the barriers, they score particularly high on perceptions of the renovation taking too much time, on lack of money, difficulty of finding information, a lack of ability to decide what to do, and a lack of capable contractors. They score lower on perceptions of it not being the right time to act.

3.5 Implemented energy efficiency actions

In the one-year follow-up, the participants of the energy counseling website survey were contacted again and asked if they implemented the planned actions. 201 participants (46.0% of all participants) gave permission to be contacted a year after the initial



survey was completed, and 78 (38.8% of all who were willing to be contacted) answered the short follow-up survey.

Of the 78 participants, 25 stated that they implemented the energy efficiency upgrades that they were planning to implement (32.1%). 29.2% of these changed at least 50% of the outer walls, 45.8% worked on the roof, 45.8% on the windows, and 37.5% on the foundation walls.

Of the 25 who implemented the measures, 15 added at least 5 cm insulation to the walls, 13 installed highly efficient windows ($\mu = 1.0$ or smaller), 13 installed new mechanical ventilation, 12 insulated the roof with at least 10 cm additional insulation, 10 insulated the foundation walls with at least 5 additional cm of insulation, and 7 installed a balanced ventilation system. In addition to these measures, 11 installed heat pumps, 11 installed clean-burning wood stoves, and 5 installed solar panels on their houses. Overall, the measures taken were fairly ambitious.

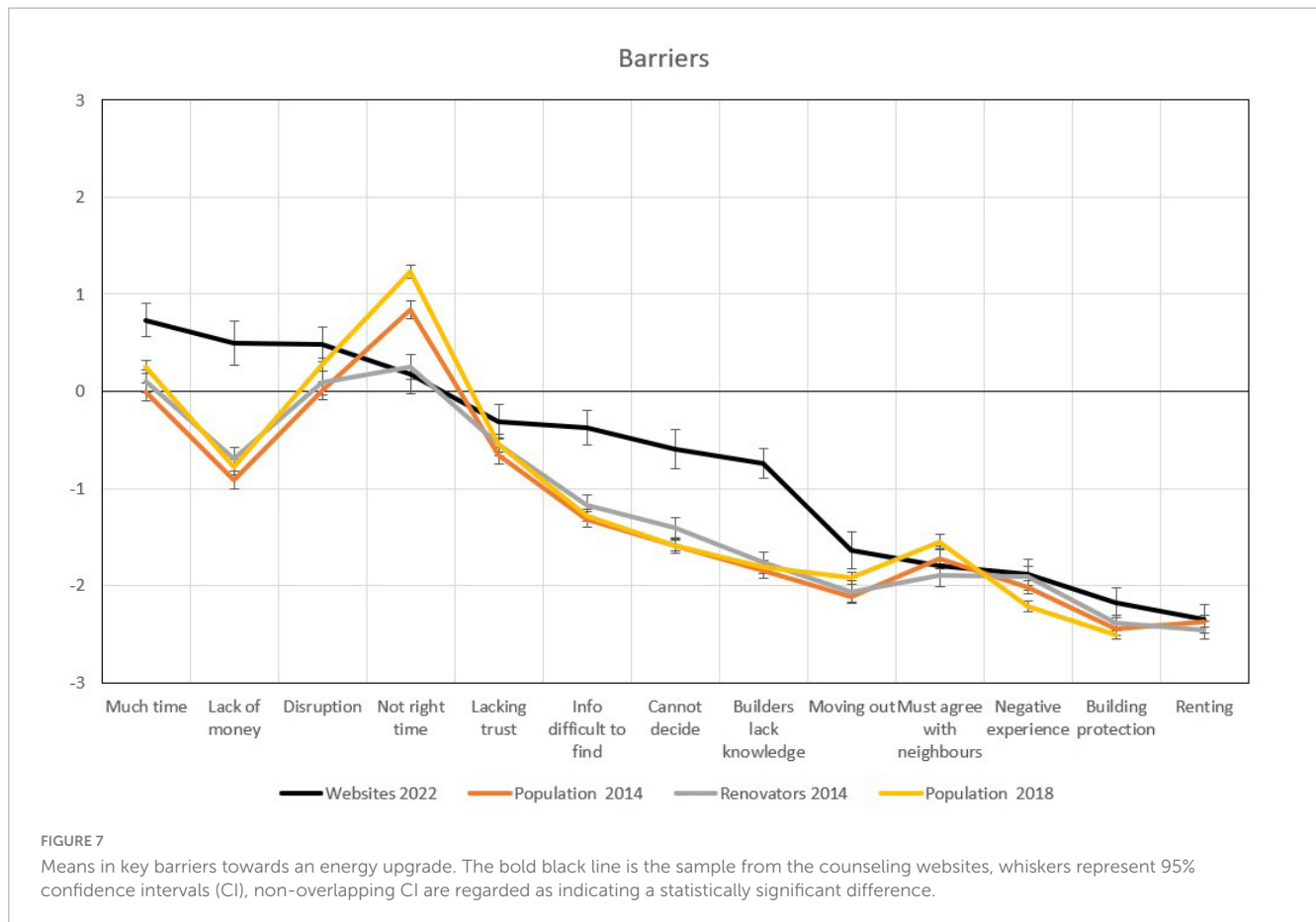
The main reasons for not implementing the planned measures among the remaining participants of the follow-up were lack of economic funding (57.1%), lack of subsidies (42.9%), and that the time was not right, yet, to start the renovation, again reflecting some of the main barriers indicated in the introduction.

4 Discussion

The study conducted with the users of two energy efficiency counseling websites had three aims: (a) finding out if users of the website differed from representative samples of Norwegian

households in terms of engagement in retrofits and have higher ambitions for their renovation projects and the energy efficiency measures embedded in them, (b) finding out if they differ in the psychological profile in central variables driving the decision-making process, and (c) finding out if they perceive facilitators and barriers in this process differently than representative samples of households. Furthermore, a follow-up study aimed to find out how many participants implement their ambitions up to a year later.

For all three main questions, we find substantial differences. Whereas the website users are mostly comparable to the general population of Norwegian households regarding socio-demographics (but have a higher education level and an even smaller percentage of people renting their dwelling, which reflects well the drivers for renovation projects as identified by [Pardalis, 2021](#)), their psychological profile differs in two important points. Compared to all other samples (also including the renovators studied in 2014), the website users have far higher levels of personal norms—they feel they really should do something about the energy standard of their homes—and also higher social norms. Considering the importance of these two factors for intentions to implement energy renovations ([Klöckner and Nayum, 2017, 1014](#)), this finding is relevant. Having such high levels of these two variables makes it more likely that people will form intentions to improve the energy standard of their homes. It also indicates that people like these are a prime target group for interventions like OSSs: They are already motivated to take action because they have high energy-related moral standards, and they feel the social pressure of their peer groups.



Since we could not survey these people before they went to the website, we do not know if they had such high personal and social norm values already before the visit to the website. On the other hand, since one of the websites is promoted by the environmental organization Friends of the Earth Norway, it can be assumed that this is the case. Interestingly, users of the counseling websites had a slightly lower level of self-efficacy, especially compared to the renovators from 2014. This implies that a lower level of self-efficacy might be a barrier to implement the intentions they form, and maybe also a reason for visiting the websites. Again, this means that this group is a very attractive target group for OSS-type interventions: Alleviating the low self-efficacy is something a well-designed OSS can achieve by reducing uncertainties, providing requested information, and not the least making the link between the urge to act on the side of the homeowners and the competence the homeowners are lacking provided by skilled and trustworthy contractors. This finding is, again, very much in line with what [Pardalis \(2021\)](#) found as being the most important features of OSSs from the perspective of potential users.

Also in terms of facilitators and barriers analysed, counseling website users had some values substantially different from the other groups. In particular, increased expected comfort levels, expected cost reductions, and expectations of having a better house to live in after the renovation were more important facilitators for website users than for the population samples or the renovators. Expecting an increased value of the house after the renovation was also

higher than for the population samples, but at the same level as for the renovators. Perceiving the current energy standards a waste was standing out again for the website users. This indicates that they enter the process with a different, more energy interested perspective (or they get convinced of that by visiting the website). Interestingly, counseling website users score lower on perceptions that information is easy to find, and that access to subsidy is available. Maybe this is also a reason why they ended up on the websites in the first place.

Among the barriers, the website users mention a lot more often the time demand for supervision and the lack of money as the main barriers. They thereby raise the need to have a facilitator (or even a manager) of the renovation process, again a function OSSs typically fill. The websites we studied are following a facilitation model, but still leave the management of the project to the homeowners. From their answers, we can conclude that many of them would actually prefer a more comprehensive model. Also here, they reiterate that they consider information hard to find, that they cannot decide what to do, and that contractors lack competence. The latter three again might be reasons for being interested in the website services in the first place. The websites seem to partly satisfy their needs, as can be seen in that a significant amount of the website visitors implement their renovation plans within a year. However, some still sit with the same lack of support and the same barriers after a year. Maybe for them, a more comprehensive OSS model with a higher degree of process management would be

more appropriate. In line with the renovators from 2014, the website users are to a lesser degree unsure if the right point in time for a renovation project has come. Overall, the order of importance of renovation facilitators and barriers to a large extent reproduces what has been found in earlier studies (Klößner et al., 2013; Klößner and Nayum, 2016, 2017; Bertoldi et al., 2021; Xue et al., 2022).

Most importantly, we found that the visitors of the websites had stronger ambitions for their renovation projects, and in particular for the implementation of energy efficiency measures as part of them. Of course, we do not know if this was caused by visiting the websites or if it was already higher before they visited. Nevertheless, we can assume that there is at least some mutual influence. People with a stronger motivation, but who are unsure about how to implement, visit the websites, which then confirm their motivations and provide hands-on counseling to remove the implementation barriers. This then eventually might result in higher ambitions. This is good news for the OSS concept, even the low-threshold version of it that these websites represent (McGinley et al., 2020). However, not all visitors seem to receive from these websites what they need. For the future, it might be recommendable to use low-threshold OSSs like the ones studied here following a facilitating model as an entry point but implement an (automated, maybe AI-based) detection of who would benefit from more comprehensive OSS models to channel these people to the offers that better suit their needs.

Finally, we could at least tentatively show—even if based upon only relatively few cases and subject to large sample attrition—that about 1/3 of the participants manage to implement their energy upgrade intentions. These people usually combine several measures and implement a deep renovation. For these people, the websites seem to have pushed them in the right direction without too much effort. As such, these websites have their niche as gatekeepers for a deeper process for some people, as the final push and reassurance for others.

5 Limitations and future research needs

Even if the study presented here shows some interesting results in a field where more research is needed, there are a number of limitations that are mostly caused by the design we had to choose. The biggest limitation of this study is that the participants recruited among the website users were, for obvious reasons, not randomly assigned to use the website but self-selected, and they were not surveyed before the visit on the website, a limitation that was already discussed in the methodology section. In addition, the users of the website fall into a narrower sociodemographic category than the population samples, though they seem to be rather comparable with people engaged in renovation projects six years prior to our study. Furthermore, we do not know how long people stayed on the websites, what they read, and how much they used the information to adapt their renovation strategy.

To address these limitations, studies with more controlled experimental designs would be advisable. Assigning participants randomly to different conditions (including no OSS, and different

models of OSS) would give a better understanding of what the effects of the OSS are and what differences people come with in the process. Such a study could also test, whether different forms of OSS interact with different sociodemographic and psychological profiles of homeowners. In simple words, it might answer the question, which form of OSS works for which type of homeowner.

6 Conclusion

One-stop-shops have been promoted as a measure to overcome the inertia in energy efficiency retrofitting, especially in the privately owned residential building stock. Results from our study on users of two Norwegian energy efficiency counseling websites, which offer services in many ways similar to an OSS following a facilitator model, show that the users of these websites clearly differ from representative samples of Norwegian households that were surveyed with similar instruments. Their profiles were more like a sample of people who were in the beginning or in the middle of a larger renovation project, which was surveyed in 2014. However, the results also show that they are scoring substantially lower on their perceived access to information and subsidy. Regarding the psychological profiles, they were much more strongly motivated by personal and social norms than average households. Most importantly, it appears that visitors of such low-threshold websites have substantially higher ambitions for the energy upgrades, which about 1/3 of them have implemented a year after they visited the websites. Interest in online energy efficiency counseling services seems to be impacted by societal discussions about energy and/or by energy prices, as suggested by the spike in recruitment to our survey coinciding with an energy price increase during 2022 (however, this intriguing possibility will need to be confirmed in future studies). From a policy perspective, the results are interesting because they indicate that low-threshold OSSs can be gateways capturing people who are motivated for energy efficiency upgrades but not able to make the decision for several reasons. For some of them, the services that these relatively simple online platforms can offer is already enough to reduce their uncertainty and make the missing connections. For those still not satisfied after visiting these platforms, future developments should explore whether they can be automatically directed to more comprehensive forms of OSSs.

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: <https://zenodo.org/records/10453810>.

Ethics statement

The studies involving humans were approved by the Norwegian Agency for Shared Services in Education and Research (SIKT). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing—original draft, Writing—review and editing. AN: Data curation, Formal analysis, Writing—original draft, Writing—review and editing. SV: Conceptualization, Funding acquisition, Writing—original draft, Writing—review and editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of the article. This study has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957115 as part of the ENCHANT project: www.enchant-project.eu. Data for three of the comparison groups for the analyses was extracted from two previous projects funded by the Norwegian Energy Efficiency Agency, and one comparison group was extracted from data from an ongoing project funded by the Research Council of Norway (BEHAVIOUR, Project No. 308772).

References

- Ajzen, I. (1991). The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50, 179–211. doi: 10.5964/ejop.v16i3.3107
- Ajzen, I. (1996). “The directive influence of attitudes on behavior,” in *The psychology of action: Linking cognition and motivation to behavior*, eds M. G. Peter and J. A. Bargh (New York, NY: The Guilford Press), 385–403. doi: 10.1037/0033-2909.132.5.778
- Bagaini, A., Croci, E., and Molteni, T. (2022). Boosting energy home renovation through innovative business models: ONE-STOP-SHOP solutions assessment. *J. Clean. Prod.* 331:129990. doi: 10.1016/j.jclepro.2021.129990
- Bertoldi, P., Boza-Kiss, B., Valle, N. D., and Economidou, M. (2021). The role of one-stop shops in energy renovation—a comparative analysis of OSSs cases in Europe. *Energy Build.* 250:111273. doi: 10.1016/j.enbuild.2021.111273
- Biere-Arenas, R., and Marmolejo-Duarte, C. (2022). “One stop shops on housing energy retrofit. European cases, and its recent implementation in Spain,” in *Proceedings of the international conference on sustainability in energy and buildings*, (Singapore: Springer Nature Singapore), 185–196.
- Ebrahimiagharehbaghi, S., Qian, Q. K., de Vries, G., and Visscher, H. J. (2022). Application of cumulative prospect theory in understanding energy retrofit decision: A study of homeowners in the Netherlands. *Energy Build.* 261:111958.
- Egner, L. E., Christian, A. K., and Giuseppe, P.-M. (2021). Low free-riding at the cost of subsidizing the rich. Replicating Swiss energy retrofit subsidy findings in Norway. *Energy Build.* 253:111542.
- Egner, L. E., and Klößner, C. A. (2021). Temporal spillover of private housing energy retrofitting: Distribution of home energy retrofits and implications for subsidy policies. *Energy Policy* 157:112451.
- IEA (2023). *Building*. Available online at: <https://www.iea.org/energy-system/buildings> (accessed July 01, 2024).
- Judson, E., and Maller, C. (2014). Housing renovations and energy efficiency: Insights from homeowners' practices. *Build. Res. Inform.* 42, 501–511.
- Klößner, C. (2013). A comprehensive model of the psychology of environmental behaviour—A meta-analysis. *Glob. Environ. Change* 23, 1028–1038.
- Klößner, C., and Nayum, A. (2016). Specific barriers and drivers in different stages of decision-making about energy efficiency upgrades in private homes. *Front. Psychol.* 7:1362. doi: 10.3389/fpsyg.2016.01362
- Klößner, C., and Nayum, A. (2017). Psychological and structural facilitators and barriers to energy upgrades of the privately owned building stock. *Energy* 140, 1005–1017.
- Klößner, C., Sopha, B. M., Matthies, E., and Bjørnstad, E. (2013). Energy efficiency in Norwegian households—identifying motivators and barriers with a focus group approach. *Int. J. Environ. Sustain. Dev.* 12, 396–415.
- McGinley, O., Moran, P., and Goggins, J. (2020). “Key considerations in the design of a one-stop-shop retrofit model,” in *Civil Engineering Research in Ireland vol. 5*. Available online at: <https://sword.cit.ie/ceri/2020/13/5>
- Nejat, P., Jomehzadeh, F., Taheri, M. M., Gohari, M., Zaimi, M., and Majid, A. (2015). A global review of energy consumption, CO2 emissions and policy in the residential sector (with an overview of the top ten CO2 emitting countries). *Renew. Sustain. Energy Rev.* 43, 843–862. doi: 10.1016/j.rser.2014.11.066
- Pardalis, G. (2021). *Prospects for the development of a one-stop-shop business model for energy-efficiency renovations of detached houses in Sweden*. Gothenburg: Linnaeus University Press.
- Pardalis, G., Mahapatra, K., and Mainali, B. (2022). Comparing public-and private-driven one-stop-shops for energy renovations of residential buildings in Europe. *J. Clean. Prod.* 365:132683. doi: 10.1016/j.jclepro.2022.132683
- Peng, Y., and Klößner, C. A. (2024). “Factors affecting Norwegian households' adaptive energy-efficient upgrades in response to the energy crisis,” in *Poster presented at the ECEEE summer study*, (Lac d'Alette). doi: 10.1016/j.erss.2022.102498
- Pohoryles, D., Maduta, C., Bournas, D. A., and Kouris, L. A. (2020). Energy performance of existing residential buildings in Europe: A novel approach combining energy with seismic retrofitting. *Energy Build.* 223:110024. doi: 10.1016/j.enbuild.2020.110024
- Schlacke, S., Wentzien, H., Thierjung, E. M., and Köster, M. (2022). Implementing the EU Climate Law via the 'Fit for 55' package. *Oxford Open Energy* 1:oiab002. doi: 10.1093/ooenergy/oiab002/6501634
- Schwartz, S. H., and Howard, J. A. (1981). “A normative decision-making model of altruism,” in *Altruism and helping behavior*, eds J. P. Rushton and R. M. Sorrentino (Hillsdale, NJ: Lawrence Erlbaum). doi: 10.1016/S0065-2601(08)60358-5
- Tsemekidi, T., Bertoldi, S. P., Diluiso, F., Castellazzi, L., Economidou, M., Labanca, N., et al. (2019). Analysis of the EU residential energy consumption: Trends and determinants. *Energies* 12:1065. doi: 10.1016/S0140-6736(24)00367-2
- Xue, Y., Temeljotov-Salaj, A., and Lindkvist, C. M. (2022). Renovating the retrofit process: People-centered business models and co-created partnerships for low-energy buildings in Norway. *Energy Res. Soc. Sci.* 85:102406. doi: 10.1016/j.erss.2021.102406

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1364980/full#supplementary-material>



OPEN ACCESS

EDITED BY

Christian Andreas Klöckner,
NTNU, Norway

REVIEWED BY

Eduardo Moraes Sarmento,
University of Lisbon, Portugal
Glenda Garza-Teran,
University of Sonora, Mexico

*CORRESPONDENCE

Hao He

✉ he156958505@163.com

RECEIVED 22 May 2024

ACCEPTED 09 August 2024

PUBLISHED 21 August 2024

CITATION

Bai S, Sun T and He H (2024) Exploring the emotional mechanism of consumer satisfaction in new energy vehicles: a dual-path model of intelligent and eco-friendly experiences. *Front. Psychol.* 15:1436494. doi: 10.3389/fpsyg.2024.1436494

COPYRIGHT

© 2024 Bai, Sun and He. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Exploring the emotional mechanism of consumer satisfaction in new energy vehicles: a dual-path model of intelligent and eco-friendly experiences

Shizhen Bai, Tao Sun and Hao He*

School of Management, Harbin University of Commerce, Harbin, China

New energy vehicles (NEVs) are considered a crucial means of reducing travel costs, enhancing consumer experiences, and innovating services. This paper aims to categorize the functional experiences of NEVs into two types: intelligent experience and eco-friendly experience, using a dual-path model. By analyzing 118,648 text data from automotive information and service platforms, the relevant factors influencing consumer satisfaction are explored. The research findings reveal that intelligent experience has a significantly positive impact on consumer satisfaction, whereas eco-friendly experience has a significantly negative impact on consumer satisfaction. This suggests that new energy vehicle companies need technological innovation in infrastructure and range to enhance consumer satisfaction. Furthermore, the research confirms that, when facing the intelligent experience of new energy vehicles, consumers' "rational" thinking plays a dominant role, and efficacy is an intermediate variable to enhance consumer satisfaction. On the other hand, when facing the eco-friendly experience of new energy vehicles, consumers' "emotional" thinking predominates, and identity is an intermediate variable to enhance consumer satisfaction. Additionally, the moderating effect of perceived usability is examined. When faced with the intelligent experience of NEVs, consumers with high perceived usability are more likely to generate a sense of efficiency. In the case of the eco-friendly experience of NEVs, consumers with low perceived usability are more likely to experience a sense of identity.

KEYWORDS

emotional mechanism, consumer satisfaction, perceived usability, intelligent experience, eco-friendly experience

1 Introduction

On the path to a low-carbon and zero-carbon future, breakthroughs in green low-carbon technologies, represented by NEVs, are highly anticipated. NEVs, with their clean and environmentally friendly advantages, have become an indispensable choice for consumers on the journey of car ownership. Policies proposing the ban on sales of traditional fuel vehicles by numerous countries and comprehensive electrification development strategies put forth by automotive manufacturers indicate that the global new energy vehicle industry, especially the

electric vehicle sector, will encounter more development opportunities in the next decade (Liu et al., 2023). NEVs have created various values, such as reducing travel costs and enhancing consumer experiences (Li et al., 2023).

With the growing ecological awareness among people, consumer preferences for NEVs have become a significant trend in green consumption (Zhang et al., 2020). Existing literature on factors influencing consumer satisfaction typically discusses individual consumer characteristics (Li and Shao, 2023), product attributes (Yang and Qiao, 2023), external environments (Fan and Wang, 2022), and others. However, consumers may encounter unfavorable driving experiences while using NEVs, leading to strong dissatisfaction, as evidenced by consumers expressing their discontent through numerous negative reviews (Xiong and Shu, 2023). Additionally, the potential impact of subsidy policy changes on consumer attitudes toward car purchases after the decline in subsidies is also a subject of investigation (Yang et al., 2023). The former focuses on rational or objective evaluations of NEVs, while the latter reflects consumers' emotional or subjective biases.

Previous scholars have analyzed the impact of intelligent attributes (Yu, 2020) and eco-friendly attributes of green products (Cheng et al., 2015) on consumer satisfaction. However, empirical research that comprehensively evaluates both intelligent and eco-friendly attributes in the context of NEVs is relatively scarce. Some scholars argue that environmental pollution can stimulate a sense of urgency and responsibility to protect the environment, thereby promoting green consumption (Fritzsche and Häfner, 2012). People may reduce guilt toward the environment by purchasing and driving NEVs. However, existing literature provides contradictory evidence. Some scholars have found no correlation between environmental pollution and green consumption tendencies, even suggesting that the intelligent attributes of NEVs are the primary driver of consumer satisfaction (Li et al., 2023). These contradictory conclusions underscore the importance of in-depth exploration into the relationship between the attributes of new energy vehicles and consumer satisfaction.

By reviewing the existing literature, this study identifies the inconsistent conclusions mentioned above, revealing several key issues existing in the current body of research: (1) existing studies mainly focus on individual, discrete perceived values (such as positive emotions) and their impact on consumer satisfaction (Lin et al., 2020), lacking a comprehensive study that integrates perceived values into cognitive paths and categorizes them; and (2) previous literature has explored the promotion of consumer satisfaction from the perspectives of rational (cognitive) cognition (such as planned behavior theory, norm activation theory) (Li and Shao, 2023) and emotional responses from emotional (non-rational) cognition (such as reducing environmental pollution, protecting the environment) (Li et al., 2023). However, as perceived values lead to cognitive evaluations and emotional responses, a comprehensive perspective is needed for research. This paper, based on a dual-path model, explores the impact of intelligent and eco-friendly attributes of NEVs on consumer satisfaction, as well as their moderating and mediating mechanisms. The research aims to achieve the following objectives: (1) validate the promoting role of two types of functional experiences in enhancing consumer satisfaction, providing new theoretical foundations for improving consumer satisfaction; (2) based on two cognitive "thinking" processes, consider efficacy and identity as two emotional responses serving as mediating mechanisms for the promotion of

consumer satisfaction by two types of functional experiences, with in-depth exploration of their contingency; and (3) use perceived usability to verify the boundary conditions of how the two types of functional experiences influence emotional responses.

2 Theoretical foundation and research hypotheses

2.1 The intelligent experience and eco-friendly experience of NEVs are associated with consumer satisfaction

Compared to traditional fuel vehicles, NEVs place greater emphasis on intelligent interaction with consumers and the use of clean energy in their functional design (Li et al., 2012), providing an opportunity to create sustainable value. Exploring NEVs from the perspective of consumer value perception is conducive to better applying technological innovations, enhancing consumer satisfaction, and promoting the widespread adoption of NEVs. The two key attributes of NEVs, namely intelligent attributes and eco-friendly attributes, hold significant importance for consumer satisfaction (Li et al., 2012). In contrast to traditional fuel vehicles, the intelligent attributes of NEVs focus on intelligent interaction between consumers and the vehicle, such as smart navigation (Gao et al., 2019; Peng et al., 2020), and data privacy security (Li et al., 2020). These features reflect the positive driving experience brought about by the diversified functionalities of NEVs. Simultaneously, their eco-friendly attributes manifest in low carbon emissions (Peng et al., 2020), intelligent charging (Bockarjova and Steg, 2014), providing consumers with a cleaner and cost-effective travel option.

Consumer expectations are formed based on their expectations of the vehicle's performance and features before using NEVs. Subsequent satisfaction assessments are based on the comparison between these expectations and the actual experience, forming a psychological state of satisfaction. Cronin et al. (2000) found that service quality, service value, and satisfaction may be directly related to behavioral intentions. Borghi et al. (2023) analyzed 20,166 online reviews of hotel service robots using machine learning and natural language processing techniques, revealing improved customer satisfaction through the relationship between service robots and customers. Heinen et al. (2023) studied how smart charging can successfully reduce peak demand and enhance customer satisfaction. Kumar et al. (2023) explored the determinants of customer satisfaction using online reviews of a grocery mobile application, suggesting that managers should focus on factors such as the ordering experience, delivery personnel interaction, and payment experience to improve customer satisfaction. Li et al. (2023) conducted sentiment analysis and text mining on 85,306 online reviews of eight types of typical green products in four areas on the JD e-commerce platform, finding variations in consumer preferences and concerns for different attributes of green products. Ramón (2023) found that customer attention and food quality are often used to define restaurant experiences, and the study revealed that the factors identified varied in their impact on customer satisfaction depending on the restaurant rating. Wu and Huo (2023) explored the relationship between service robots, consumer service experience perception, and consumer satisfaction, indicating a positive impact of introducing service robots in hotels on consumer satisfaction, with perceived

warmth and competence mediating this impact (Wu and Huo, 2023). Therefore, this study proposes the following hypotheses:

H1a: The intelligent experience of NEVs has a positive impact on consumer satisfaction.

H1b: The eco-friendly experience of NEVs has a positive impact on consumer satisfaction.

2.2 Emotional responses

Emotional responses represent the psychological processes and accompanying physiological reactions that individuals have to external stimuli, encompassing various sensations, thoughts, and behaviors (Berger, 2011).

In recent years, scholars have conducted in-depth research on the relationship between emotional responses and consumer satisfaction, covering multiple consumer scenarios. Previous research indicates that consumer emotional responses significantly influence subsequent satisfaction experiences, including emotional responses when facing uncertainty, which are directly related to subsequent satisfaction experiences (Xu and Guo, 2023). Guo et al. (2021) focused on apology commitment-type management feedback strategies, examining their impact on customer satisfaction and highlighting the importance of emotional regulation effects. Wang et al. (2023) studied the impact of marketing orientation on consumer regret emotions in the context of overconsumption, revealing that marketing orientation affects subsequent satisfaction experiences through its influence on responsibility attribution and self-control. Fei et al. (2021) delved into the persuasive effects of awe emotions, finding that awe emotions can influence individuals' cognitive and emotional responses, subsequently impacting satisfaction.

This study chooses to investigate emotional responses for two reasons: (1) emotional responses, different from behavioral responses, cover non-rational factors such as emotions, intuitions, cognitive and evaluative rational factors (Septianto et al., 2023), providing a better explanation for the complex psychological mechanisms that drive consumer satisfaction promoted by functional experiences; (2) emotional responses are related to consumer behavioral responses, serving as a fundamental mechanism for consumers to react to the product attributes of NEVs, prompting consumers to adopt environmentally friendly behaviors favoring new energy vehicle consumption when facing environmental pollution and the call for "dual-carbon," making it one of the essential psychological factors to enhance consumer satisfaction (Mano and Oliver, 1993).

This study integrates efficacy and identity, two different orientations and valence of emotional responses, into the research framework. Efficacy represents the emotional response to intelligent attributes, while identity represents the emotional response to eco-friendly attributes. Since intelligent attributes involve functions such as data privacy security, autonomous driving, and smart navigation, consumers' perception of these functions triggers efficacy, enhancing satisfaction. On the other hand, eco-friendly attributes involve the advantages of NEVs in low carbon emissions, smart charging, etc., and this perception triggers identity, prompting consumers to choose such vehicles more satisfactorily. Therefore, the study proposes the following hypotheses:

H2a: The sense of efficiency plays a mediating role between intelligent experience and consumer satisfaction.

H2b: The sense of identity acts as a mediating factor between eco-friendly experience and consumer satisfaction.

2.3 Perceived usability

Introducing Davis's (1989) Technology Acceptance Model, which aims to explain the determining factors of users' decisions to accept information systems. The core idea includes two major determining factors: perceived usefulness, i.e., the extent to which a person believes that using the system will enhance job performance, and perceived ease of use, i.e., the ease with which a person believes they can use the system (Davis, 1989).

Devaraj et al. (2002) found that perceived usefulness and perceived ease of use are critical determinants of consumer attitudes and indirectly impact consumer satisfaction through channel preferences. De Guinea et al. (2014) found that, in high frustration situations, neural physiological memory load has a negative impact on perceived ease of use, demonstrating the importance of emotional perception in regulating the impact of neurophysiological states on behavioral beliefs. Lee et al. (2012) found that the emotions displayed by users on Facebook activity pages significantly impact the perceived ease of use and perceived enjoyment of social media marketing (Lee et al., 2012). Gefen et al. (2003) highlighted the significance of consumer trust, as with widely accepted TAM antecedents, such as perceived usefulness and perceived ease of use, for electronic commerce. Partala and Saari (2015) found that perceived usefulness, satisfaction of psychological needs, and negative emotions significantly affect the overall perceived value of user experiences in the most influential user experiences. Pelegrín-Borondo et al. (2017) established a cognitive-emotional-normative model, confirming that emotional and normative factors have the greatest impact on the acceptance of new technology, and perceived usability has a positive impact on the generation of emotions, specifically on mood. In this study, perceived usability reflects the efficacy and identity generated by consumers when driving NEVs, thereby enhancing satisfaction. Therefore, the regulatory role of perceived usability in the respective functional experiences is crucial (Figure 1). In summary, this study proposes the following hypotheses:

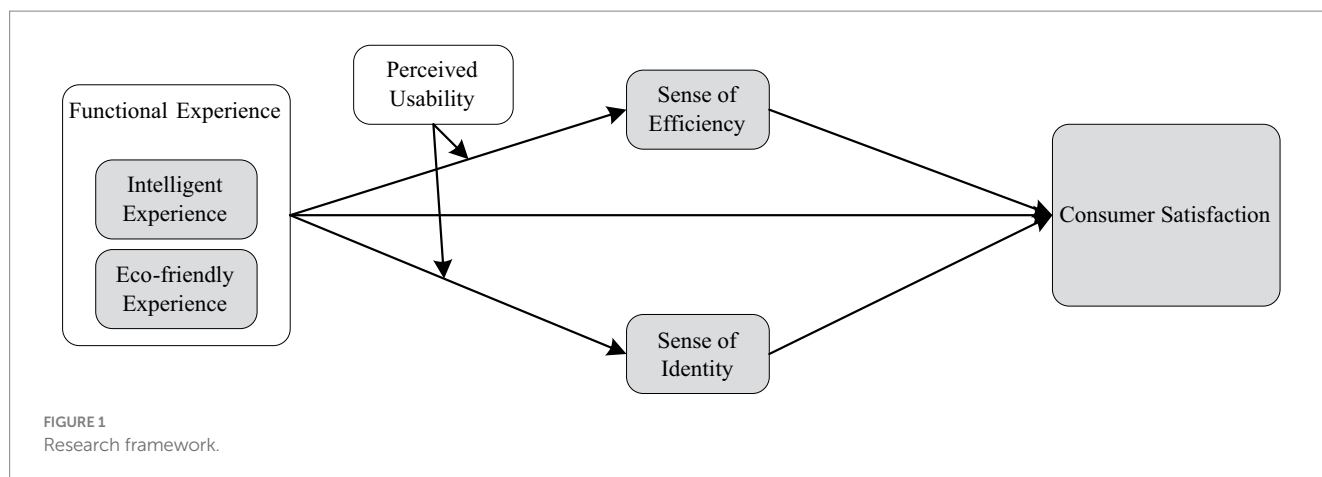
H3a: Perceived usability plays a moderating role between intelligent experience and the sense of efficiency.

H3b: Perceived usability plays a moderating role between eco-friendly experience and the sense of identity.

3 Data collection and processing

3.1 Sample selection

In the context of the global energy transition, the NEVs industry emerges as a key driver for sustainable development, playing a crucial role in both the Chinese and global markets. NEVs are gradually replacing traditional fuel vehicles, a trend that cannot be ignored.



Undoubtedly, China establishes itself as a global powerhouse in the new energy vehicle sector. NEVs in the Chinese market consistently top global production and sales charts, garnering significant favor from consumers at home and abroad. This underscores the importance of exploring various factors influencing consumer satisfaction, including intelligent experience, eco-friendly experience, perceived usability, sense of efficiency, sense of identity, consumer satisfaction, and functional experiences.

Notably, on January 31, 2024, the renowned domestic new energy vehicle business intelligence data service provider, QuestAuto, released the “2023 New Energy Vehicle Market Report.” The report indicates that the new energy vehicle market experienced a significant surge in 2023, not only witnessing a substantial increase in sales but also a remarkable rise in active increments. Chinese domestic brands, in particular, presented a flourishing scenario of diversity.

In this study, we have selected NEVs as our research samples, aiming to delve into the impact of innovative and environmentally friendly vehicle models on consumer satisfaction. Given the leading position of NEVs in technology, environmental protection, and sustainability, the academic community has paid special attention to this field. NEVs not only represent a technological upgrade from traditional fuel models but also attract widespread attention due to their unique functional experiences. Furthermore, through the analysis of user reviews, we can capture the genuine feelings and opinions of consumers, providing a unique perspective for a deeper understanding of the intrinsic drivers of satisfaction. Finally, studying NEVs helps understand consumers’ psychological reactions when facing innovative products, offering targeted market strategies and product design recommendations for automotive manufacturers.

3.2 Data sources and explanation

This study utilized online reviews of 32 NEVs from three prominent automotive information and service platforms as the primary data source. These three platforms are “Autohome,” “PacAuto,” and “Yiche,” each enjoying outstanding recognition in the automotive industry. They offer users timely and comprehensive services such as automotive user reviews, vehicle information, and model evaluations, providing crucial references and support for consumer car purchasing decisions.

To obtain data, a Python based scraping program is employed in a targeted manner to extract user comments about 32 NEVs from the three platforms. During the data collection process, a specific collection template was used, and by November 25, 2023, a total of 118,648 data items, including user ID, comment text, comment date, rating, and vehicle model, were successfully collected. These data were stored in CSV format, providing a comprehensive and robust foundation for subsequent analysis.

3.3 Data preprocessing

3.3.1 Noise data eliminating

In the data collection process, due to the substantial workload and frequent operations, some duplicated, incorrect, invalid, and meaningless data inevitably occurred, resulting in non-standardized data presentation on the page. To ensure the accuracy of subsequent analyses, this study referred to previous experiences (Wang et al., 2022) and meticulously cleaned the 118,648 original comments, eliminating duplicates, invalid reviews unrelated to the product, comments composed of emoticons and special characters, and low-reference-value reviews. After the data elimination process, this study obtained a total of 86,502 valid new energy vehicle comments.

Typically, consumer comments on e-commerce platforms are more colloquial and lack standardized structures or uniform formats. Therefore, before proceeding with further analysis, the data required additional processing, including segmentation and stop-word removal, to convert it into a machine-readable form. Referring to previous relevant studies (Berger et al., 2020), this study, in the cleaned comments, utilized authoritative Chinese and international *jieba* segmentation and stop-word tables for segmentation operations and removal of stop words.

3.3.2 STM topic model and LIWC

STM (Structural Topic Model) is a topic model used for text data analysis, exhibiting outstanding performance in text topic modeling. STM can effectively capture structural relationships between documents. In this study, we used the comment time and rating of new energy vehicle comments as popularity covariates, inputting them into STM for topic extraction. After experimental

validation, when the number of topics was set to 27, STM demonstrated the optimal extraction performance, showing good semantic consistency and exclusivity in training results. We labeled each topic based on its most representative words, combined with domain knowledge (Tsui et al., 2010; Chuah et al., 2021), and summarized the types of topics. Subsequently, we selected topics related to intelligent and environmentally friendly attributes to explore consumer functional experiences as variables validating increased satisfaction. Additionally, we selected topics related to perceived usability values (Wolf and Seebauer, 2014; Liu and Park, 2015) to uncover consumer perceptual tendencies as variables validating the relationship between functional experiences and emotional responses (Figure 2).

This study is based on the Python language and the LIWC (Linguistic Inquiry and Word Count), conducting in-depth analysis of language proficiency and preferences among different categories in the text. LIWC reads a text, the text analysis module then compares each word in the text against a user-defined dictionary. The dictionary identifies which words are associated with which psychologically-relevant categories. After read and accounted for all words in a given text, it calculates the percentage of total words that match each of the dictionary categories. We employed LIWC for a detailed examination of emotional and psychological factors. Through text feature

extraction, we calculated the proportions of various textual features, including the percentage of multifunctional words and positive emotion words. Among these multifunctional words, we further extracted the sense of efficiency, while in positive emotion words, we extracted the sense of identity. These were used as intermediary variables to validate the relationship between functional experiences and consumer satisfaction.

In summary, this study utilizes the proportions of topics related to functional experiences and perceived values, the proportions of text features analyzed by LIWC, and user ratings as the basis for analysis.

4 Results and discussion

4.1 Main effect tests

To begin with, we employ SPSS 25.0 for descriptive statistics and correlation analysis on various variables, and the detailed results can be found in Table 1. There exists a significant correlation ($p < 0.05$) among intelligent experience, eco-friendly experience, perceived usability, sense of efficiency, sense of identity, and consumer satisfaction.

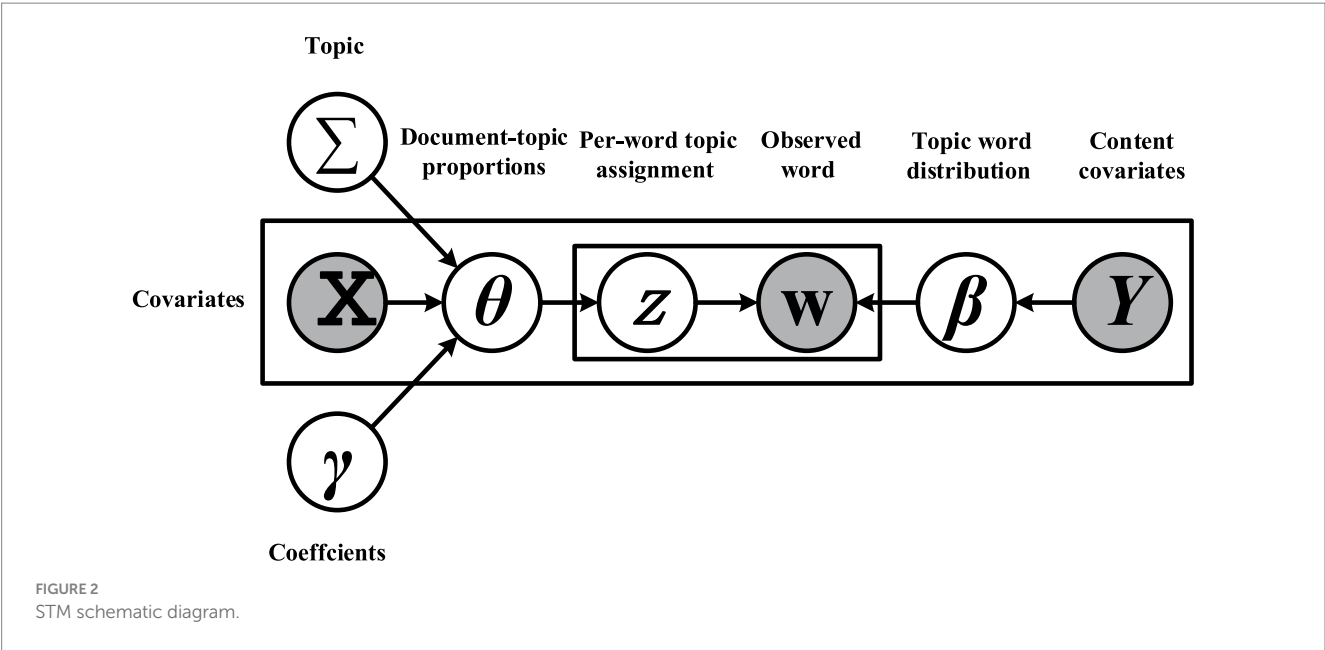


TABLE 1 Descriptive statistics and correlation analysis of variables.

	<i>M</i>	<i>SD</i>	Intelligent experience	Eco-friendly experience	Perceived usability	Sense of efficiency	Sense of identity	Consumer satisfaction
Intelligent experience	0.04	0.05	1					
Eco-friendly experience	0.03	0.05	−0.047**	1				
Perceived usability	0.03	0.04	0.050**	0.312**	1			
Sense of efficiency	0.10	0.03	−0.020**	0.074**	0.093**	1		
Sense of identity	0.04	0.01	−0.124**	−0.040**	0.092**	−0.128**	1	
Consumer satisfaction	4.54	0.44	0.090**	−0.057**	0.01**	0.059**	−0.015**	1

Furthermore, linear regression analyses were conducted to examine the relationships between intelligent experience, eco-friendly experience, and consumer satisfaction. The results, as presented in Table 2, reveal a significant positive impact of intelligent experience on consumer satisfaction ($p < 0.001$, $\beta = 0.090$). Therefore, hypothesis H1a is supported, indicating a close association between technological innovation and the application of intelligent features in NEVs and consumer satisfaction.

Firstly, the technological innovations in intelligent assisted driving and voice recognition contribute to the convenience, safety, and comfort of the driving process, significantly enhancing overall consumer satisfaction. This may be attributed to the personalized driving experiences facilitated by intelligent technologies (Cui et al., 2019), further reinforcing user acceptance and satisfaction with NEVs. Secondly, the convenience and safety improvements brought about by intelligent experience not only meet consumers' expectations for vehicle performance but also strengthen their positive perceptions of NEVs. Through a more intelligent driving experience, consumers are more likely to establish trust in NEVs, thereby promoting an increase in their satisfaction.

The eco-friendly experience ($p < 0.001$, $\beta = -0.057$) exhibits a significant negative impact on consumer satisfaction, thus rejecting the hypothesis H1b. The environmentally friendly attributes of NEVs may, under specific conditions, result in a negative influence on consumer satisfaction. Firstly, the eco-friendly attributes of NEVs

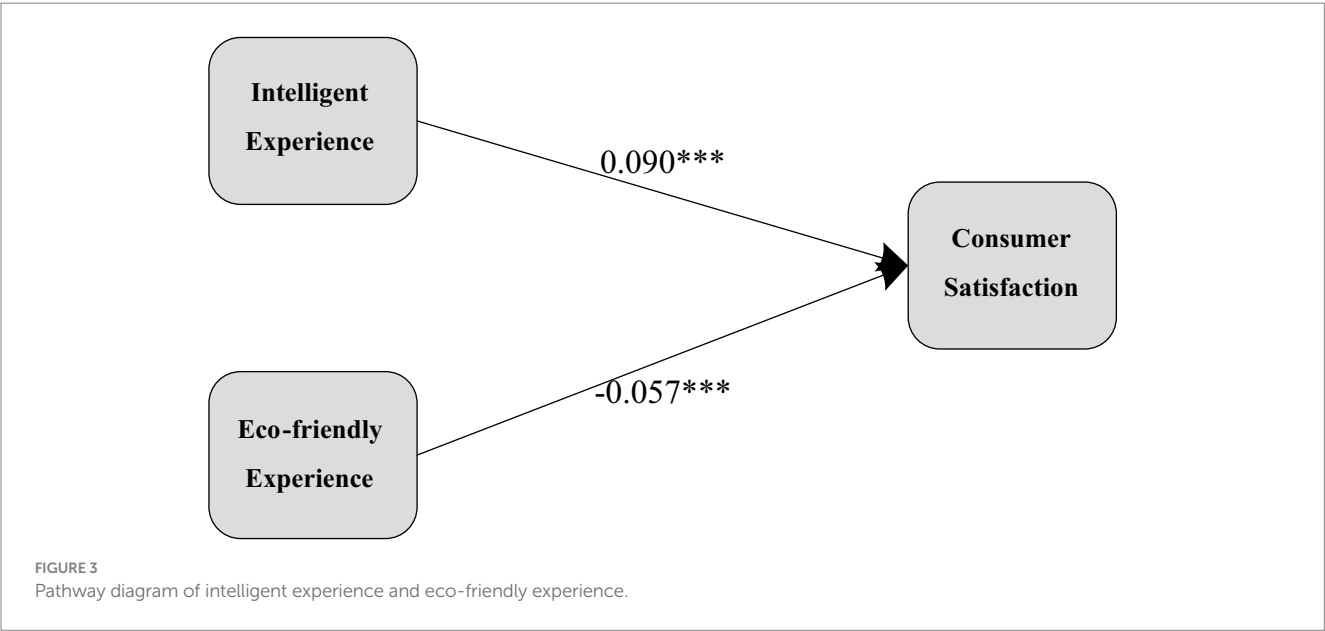
have a detrimental effect on the driving experience for consumers under low-temperature conditions, such as concerns related to battery range and travel costs (Whitehead and Wicker, 2018). This could lead to inconvenience and additional expenses for consumers in cold environments, consequently diminishing their overall satisfaction with NEVs. Secondly, in cold conditions, the increased operational costs of NEVs may not solely result from a decline in battery range but also encompass additional energy consumption by the heating system. To maintain a comfortable interior temperature, vehicles may require additional power supply for heating devices, thereby diminishing the available energy in the battery and consequently affecting the overall range performance. These factors contribute to a reduced practicality of electric vehicles in specific environments, subsequently amplifying consumer misunderstandings and dissatisfaction. The intelligent experience of NEVs is compromised under such circumstances, highlighting the intricate interplay between eco-friendly experiences, perceived usability, sense of efficiency, and consumer satisfaction (Figure 3).

4.2 Mediation effect tests

To examine the mediating role of emotional responses in the impact of functional experiences on consumer satisfaction, this study employs the Bootstrap method for analysis, with a sample size of

TABLE 2 Linear regression analysis.

	Unstandardized coefficient		Standardized coefficient	<i>t</i>	Significance
	<i>B</i>	Standard deviation	Beta		
(Intercept)	4.504	0.002		2331.211	0.000
Intelligent experience	0.818	0.031	0.090	26.550	0.000
(Intercept)	4.555	0.002		2417.092	0.000
Eco-friendly experience	−0.563	0.033	−0.057	−16.935	0.000



5,000. The analysis was conducted using Model 4 from the PROCESS macro program in SPSS, with a 95% confidence interval. Tables 3, 4 respectively present the results of the mediating effects of the sense of efficiency and the sense of identity.

According to the research results presented in Table 3, introducing the mediating variable, the sense of efficiency, the total effect showed significance ($p < 0.001$, $\beta = 0.818$). Upon closer inspection, both the direct effect ($p < 0.001$, $\beta = 0.031$) and the mediating effect of the sense of efficiency are significant ($\beta = -0.011$, $SE = 0.002$, $95\%CI = [-0.014, -0.007]$), providing clear support for the validity of hypothesis H2a. The detailed diagram illustrating the mediating pathways can be found in Figure 4. This series of findings strongly indicates that the sense of efficiency plays a crucial mediating role in the impact of intelligent experiences on consumer satisfaction.

When consumers driving NEVs perceive intelligent attributes, a “pleasure” thought pattern dominates their emotional responses, triggering a sense of efficiency. This emotional response, through partial mediation, further elevates the level of consumer satisfaction. The joy and convenience brought about by intelligent experiences trigger the “pleasure” emotional response (Kim and Park, 2019), which, through the mediating role of the sense of efficiency, enhances overall satisfaction with the experience. Therefore, we can conclude that the sense of efficiency plays a

critical mediating role in the impact of intelligent experiences on consumer satisfaction.

The sense of efficiency is a psychological perception of individuals toward the abundant and powerful functions of NEVs, closely linked to the “pleasure” thought pattern. When consumers perceive intelligent attributes, their thought patterns are guided toward a state of enjoyment and pleasure (Alalwan, 2020), resulting in a sense of efficiency. This emotional cognition, through partial mediation, further increases overall satisfaction levels. The joy and convenience brought about by intelligent experiences act as triggering factors for the “pleasure” emotional response, and the sense of efficiency, as a mediator, profoundly connects the relationship between emotional responses and satisfaction.

According to the results presented in Table 4, after incorporating the mediating variable, the sense of identity, into the model, the total effect showed significance ($p < 0.001$, $\beta = -0.563$). Further observation reveals that both the direct effect ($p < 0.001$, $\beta = -0.570$) and the mediating effect of the sense of identity were significant ($\beta = -0.007$, $SE = 0.002$, $95\%CI = [0.004, 0.010]$), providing robust support for hypothesis H2b. The corresponding diagram illustrating the mediating pathways can be found in Figure 5. This series of results clearly indicates that in the impact of eco-friendly experiences on consumer satisfaction, the sense of identity plays a partial mediating role.

When consumers driving NEVs perceive eco-friendly attributes, their thought patterns are primarily influenced by “compliance,” triggering emotional responses and ultimately generating a sense of identity (Kunkel et al., 2021). This emotional response, through partial mediation, further enhances consumer satisfaction. The mediating role of the sense of identity in eco-friendly experiences further emphasizes that in the market promotion of NEVs, eco-friendly attributes serve not only to meet societal expectations but also, by triggering a sense of identity, enhance overall consumer satisfaction. Therefore, the sense of identity plays a positive mediating role in the impact of eco-friendly experiences on consumer satisfaction.

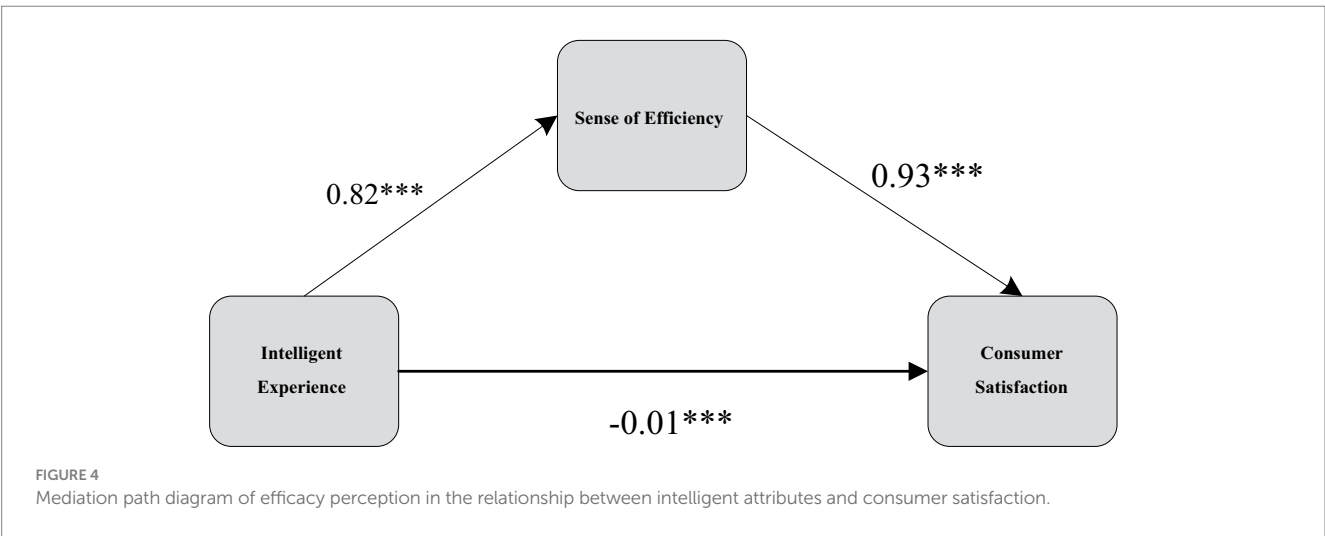
The thought pattern of “compliance” triggered by eco-friendly attributes generates a sense of identity among consumers, leading them to more positively experience eco-friendly attributes (Carter and Gilovich, 2012). The sense of identity, as an emotional cognition, through partial mediation, further influences consumer satisfaction. Therefore, the sense of identity not only plays a role in meeting societal expectations but also, on an emotional level, by strengthening

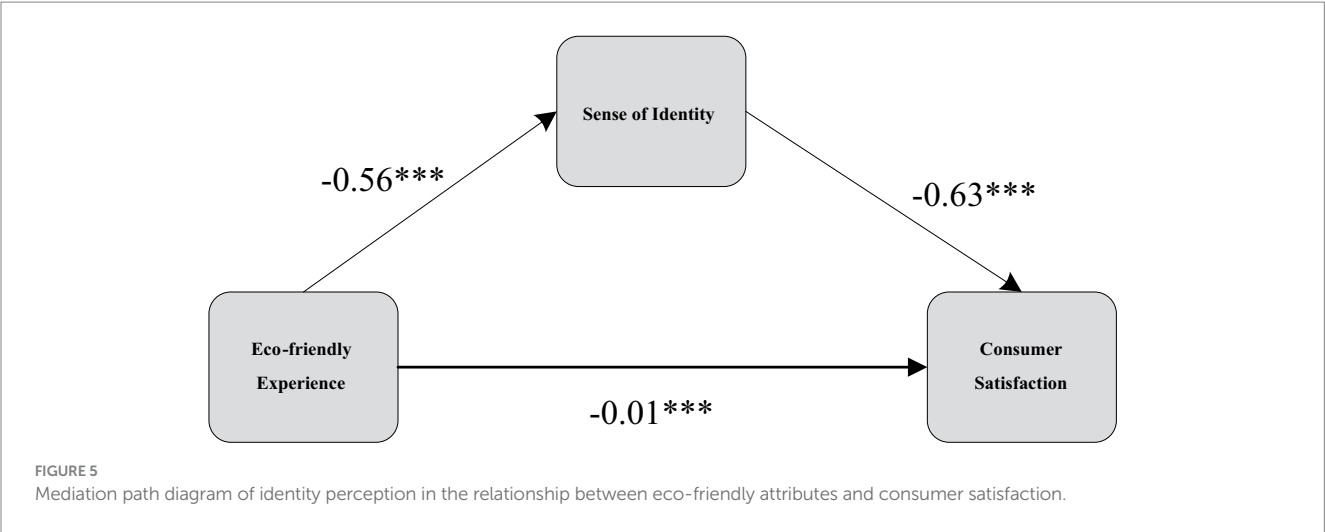
TABLE 3 Mediation analysis of efficacy perception.

	Effect	SE	t	p-value	LLCI	ULCI
Total effect	0.818	0.031	26.550	0.000	0.758	0.879
Direct effect	0.829	0.031	26.945	0.000	0.769	0.889
Indirect effect	−0.011	0.002			−0.014	−0.007

TABLE 4 Mediation analysis of identity perception.

	Effect	SE	t	p-value	LLCI	ULCI
Total effect	−0.563	0.033	−16.935	0.000	−0.628	−0.498
Direct effect	−0.570	0.033	−17.125	0.000	−0.635	−0.504
Indirect effect	0.007	0.002			0.004	0.010





consumer identification with eco-friendly experiences, enhances overall satisfaction levels.

4.3 Moderation effect tests

To examine the moderating effect of perceived usability in the mediating model involving functional experiences, emotional responses, and consumer satisfaction, this study utilized the Bootstrap method for analysis with a sample size of 5,000. The analysis, conducted at a 95% confidence interval, employed Model 7 from the PROCESS macro program in SPSS. Tables 5, 6 respectively display the results of the moderating effect of perceived usability.

4.3.1 Moderating effect of perceived usability on the relationship between smart experience and efficiency perception

As shown in Table 7, smart experience significantly negatively influences efficiency perception ($p < 0.001$, $\beta = -0.016$), while efficiency perception has a significant positive impact on consumer satisfaction ($p < 0.001$, $\beta = 0.934$). Notably, in this context, smart experience also exhibits a significant positive influence on consumer satisfaction ($p < 0.001$, $\beta = 0.829$), indicating that efficiency perception acts as a partial mediator between smart experience and consumer satisfaction. This finding emphasizes the crucial role of efficiency perception in the overall formation process of consumer satisfaction.

In Table 5, perceived usability ($p < 0.001$, $\beta = -0.015$, 95%CI=[-0.019, -0.011]) also exhibits significance in terms of mediating effects. The results reveal that the interaction term between smart experience and perceived usability significantly affects efficiency perception ($p < 0.001$, $\beta = -0.778$). Further simple slope analysis reveals a significant positive impact of smart experience on efficiency perception in individuals with low perceived usability ($p < 0.001$, $\beta = 0.009$, 95%CI=[0.004, 0.014]). However, in individuals with high perceived usability, smart experience significantly negatively influences efficiency perception ($p < 0.001$, $\beta = -0.049$, 95%CI=[-0.055, -0.043]). This result suggests that perceived usability plays a significant moderating role in the relationship between smart experience and efficiency perception.

TABLE 5 Sense of efficiency of total effects, direct effects, and indirect effects (bootstrap = 5,000).

Sense of efficiency	Effect	Boot SE	Boot LLCI	Boot ULCI
Total effect	0.009	0.002	0.004	0.014
Direct effect	-0.015	0.002	-0.019	-0.011
Indirect effect	-0.046	0.004	-0.053	-0.039

TABLE 6 Sense of identity of total effects, direct effects, and indirect effects (bootstrap = 5,000).

Sense of identity	Effect	Boot SE	Boot LLCI	Boot ULCI
Total effect	0.011	0.003	0.006	0.017
Direct effect	0.005	0.001	0.003	0.008
Indirect effect	-0.003	0.001	-0.006	-0.002

A more in-depth analysis of indirect effects indicates that, for individuals with low perceived usability, smart experience further promotes consumer satisfaction by enhancing the positive impact on efficiency perception ($p < 0.001$, $\beta = 0.009$, 95%CI=[0.004, 0.014]). Conversely, in individuals with high perceived usability, the negative impact of smart experience on efficiency perception slows down the positive effect on consumer satisfaction ($p < 0.001$, $\beta = -0.046$, 95%CI=[-0.053, -0.039]). The significant difference in indirect effects between high and low levels is noteworthy, with a difference of -0.054, 95%CI=[-0.064, -0.046], $p < 0.001$, confirming the validity of H3a. This further validates the moderating role of perceived usability in the relationship between smart experience and consumer satisfaction.

On the one hand, individuals with low perceived usability may have lower adaptation levels when facing new technologies. Therefore, they are more likely to generate positive experiences with the innovative and convenient aspects of the intelligent attributes of NEVs. This positive experience may stimulate their sense of efficiency, thereby enhancing overall satisfaction. These individuals may be more willing to accept and attribute high value to the positive effects brought about by intelligent experiences because it may provide them

TABLE 7 Regression analysis results of relevant variables in the moderated mediation model.

Variable	Sense of efficiency		Sense of identity		Consumer satisfaction	
	β	p -value	β	p	β	p -value
Intelligent experience	−0.016	0.000			0.829	0.000
Sense of efficiency					0.934	0.000
Intelligent experience* sense of efficiency	−0.778	0.000				
Eco-friendly experience			−0.008	0.000	−0.570	0.000
Sense of identity					−0.629	0.000
Eco-friendly experience* sense of identity			0.314	0.000		

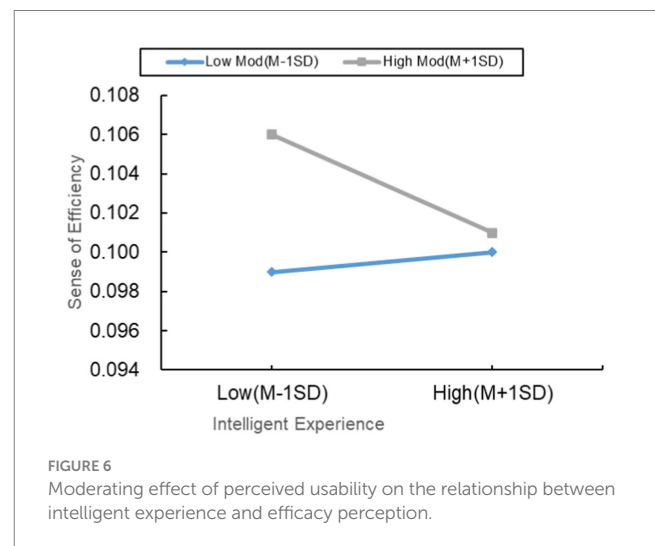
with more learning and growth opportunities (Thompson et al., 2005), subsequently elevating their recognition of the intelligent attributes of NEVs. Conversely, for individuals with high perceived usability, who have already established expectations for highly usable technology, they may hold relatively high standards for the performance and convenience of these technologies. When the intelligent attributes of NEVs fail to meet these high expectations, it may lead to a decrease in the sense of efficiency, thus slowing down the positive impact on overall satisfaction. This group may be more sensitive to the shortcomings of the technology because they have already established higher expectations in terms of usability.

On the other hand, individuals with high perceived usability may have higher expectations for the functionality and operation of NEVs. Therefore, if the intelligent experience fails to meet these expectations, it may result in a decreased sense of efficiency, thereby reducing overall satisfaction (Hong et al., 2017). This suggests that, for this group, intelligent experiences need to align with their high expectations (Belanche et al., 2021) to ensure that their overall evaluation of the intelligent attributes of NEVs remains positive. In contrast, for individuals with low perceived usability, their expectations for new energy vehicle technology may be relatively low. Even if the sense of efficiency from the intelligent experience is limited, they may still generate positive satisfaction with the vehicle. This could be because they place more emphasis on the basic functionalities of NEVs, and their requirements for advanced technology are relatively low, making them more easily satisfied. The moderating effect of perceived usability on the sense of efficiency is illustrated in Figure 6.

4.3.2 Moderating effect of perceived usability on the relationship between environmental experience and identity perception

As shown in Table 7, environmental experience significantly negatively influences identity perception ($p < 0.001$, $\beta = -0.008$), while identity perception has a significant negative impact on consumer satisfaction ($p < 0.001$, $\beta = -0.629$). Importantly, in this context, environmental experience has a significantly positive influence on consumer satisfaction ($p < 0.001$, $\beta = -0.570$), indicating that identity perception acts as a partial mediator in this process. This finding emphasizes the crucial mediating role of identity perception in the relationship between environmental experience and consumer satisfaction.

As presented in Table 6, perceived usability ($p < 0.001$, $\beta = 0.005$, 95%CI = [0.003, 0.008]) also shows significance in terms of mediating effects. The results reveal that the interaction term between environmental experience and perceived usability



significantly affects identity perception ($p < 0.001$, $\beta = 0.314$). Further simple slope analysis indicates a significant positive impact of environmental experience on identity perception in individuals with low perceived usability ($p < 0.001$, $\beta = -0.018$, 95%CI = [−0.021, −0.016]). However, in individuals with high perceived usability, environmental experience significantly negatively influences identity perception ($p < 0.001$, $\beta = 0.005$, 95%CI = [0.003, 0.007]). This result suggests that perceived usability plays a significant moderating role in the relationship between environmental experience and identity perception.

Further indirect effects analysis reveals that, for individuals with low perceived usability, environmental experience further promotes consumer satisfaction by enhancing the positive impact on identity perception ($p < 0.001$, $\beta = 0.011$, 95%CI = [0.006, 0.017]). However, for individuals with high perceived usability, the negative impact of environmental experience on identity perception leads to a decrease, weakening the positive impact on consumer satisfaction ($p < 0.001$, $\beta = -0.003$, 95%CI = [−0.006, −0.002]). The significant difference in indirect effects between high and low levels is noteworthy, with a difference of −0.015, 95%CI = [−0.022, −0.008], $p < 0.001$, further confirming the moderating role of perceived usability in the relationship between environmental experience and consumer satisfaction. In summary, assuming H3b is valid, perceived usability plays a moderating role in the relationship between environmental experience and consumer satisfaction (Table 8).

Firstly, for individuals with lower perceived usability, they are more likely to integrate the eco-friendly experience into their positive

TABLE 8 Summary of hypothesis tests.

Hypotheses	Support
H1a: Perceived intelligent attributes of new energy vehicles have a positive impact on consumer satisfaction.	Yes
H1b: Perceived eco-friendly attributes of new energy vehicles have a positive impact on consumer satisfaction.	No
H2a: Efficacy mediates the positive impact of perceived intelligent attributes on consumer satisfaction.	Yes
H2b: Identity mediates the positive impact of perceived eco-friendly attributes on consumer satisfaction.	Yes
H3a: Perceived usability moderates the relationship between functional experiences triggered by intelligent attributes and efficacy.	Yes
H3b: Perceived usability moderates the relationship between functional experiences triggered by eco-friendly attributes and identity.	Yes

perception of NEVs (Gulzari et al., 2022), as they adapt more easily to the new environmental attributes. In their car purchasing decisions, these individuals place greater emphasis on the eco-friendly performance of NEVs, thereby increasing their satisfaction. Through the moderation of perceived usability, the eco-friendly experience has a positive impact on consumer satisfaction. Conversely, for individuals with higher perceived usability, they may pay more attention to other aspects of NEVs, such as performance or appearance, potentially having a negative impact on their sense of identity with the eco-friendly experience (Prebensen and Xie, 2017). This may be because, in the car purchasing decisions of these individuals, the importance of eco-friendly attributes is relatively lower compared to other factors. In this scenario, the negative impact of the eco-friendly experience on the sense of identity is weakened, contributing to an overall enhancement of satisfaction.

On the other hand, individuals' perceptions of eco-friendly experience, sense of identity, and perceived usability may vary due to differences in culture, education level, and life experiences (Sun et al., 2020). For example, in a cultural context emphasizing environmental ideals, the role of perceived usability may be more pronounced. Additionally, individuals' education levels and life experiences may influence the importance they place on the eco-friendly attributes of NEVs. Therefore, when perceived usability is lower, individuals may be more willing to accept and identify with the eco-friendly experience. Conversely, when perceived usability is higher, they may prioritize other aspects, triggering the occurrence of moderation effects. The moderating effect of perceived usability on the sense of identity is depicted in Figure 7.

5 Research conclusion

In the face of technological constraints, this study investigates which attributes of NEVs can capture consumer attention and subsequently enhance consumer satisfaction. Initially, our focus centers on the relationship between functional experiences of NEVs and consumer satisfaction, examining the impact of different types of functional experiences on the psychological mechanisms underlying consumer satisfaction. Subsequently, we explore how two categories of functional experiences, guided by dominant intelligent and affective attributes respectively, activate distinct emotional responses through cognitive pathways to enhance consumer satisfaction. The conclusions affirm that regardless of the type of functional experience, it significantly influences consumer satisfaction with NEVs. However, different types of functional experiences exert their impact on consumer satisfaction through divergent cognitive processes and emotional responses.

Specifically, this paper elucidates the differential effects of intelligent experience and eco-friendly experience of new energy

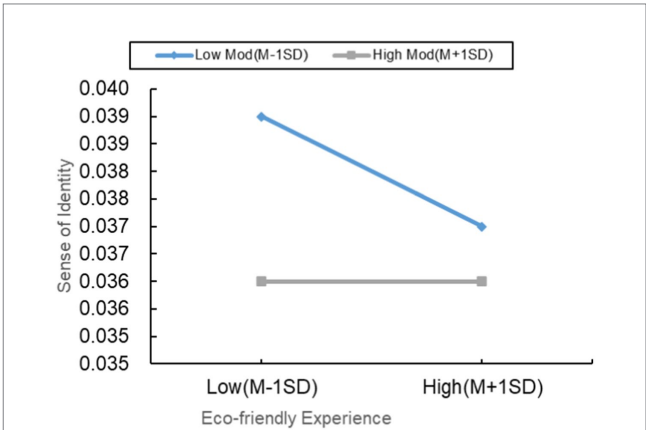


FIGURE 7
Moderating effect of perceived usability on the relationship between intelligent experience and efficacy perception.

vehicles (NEVs) on consumer satisfaction. Firstly, the intelligent experience of NEVs has a significant positive impact on consumer satisfaction. This positive effect is primarily driven by the sense of efficiency rather than the sense of identity, as the intelligent experience focuses more on the hedonic value and enjoyment of NEVs. Secondly, the eco-friendly experience of NEVs has a significant negative impact on consumer satisfaction. This negative effect is primarily driven by the sense of identity rather than the sense of efficiency, as the eco-friendly experience emphasizes the emotional value and recognition of NEVs, leading to varying levels of perceived value (González-Mansilla et al., 2019). These findings help deepen the understanding of the boundary effects of different functional experiences on consumer satisfaction. Furthermore, when consumers experience the intelligent attributes of NEVs, their “cognitive” pathway is dominant, triggering a sense of efficiency and creating a psychological “hedonic” mechanism (Wei et al., 2013). Conversely, when consumers experience the eco-friendly attributes of NEVs, their “affective” pathway takes precedence, inducing a sense of identity and generating a psychological “conformity” mechanism (Qiao et al., 2023), thereby enhancing consumer satisfaction. The hedonic value of the intelligent experience of NEVs, through the enhancement of the sense of efficiency, primarily influences the consumers’ “cognitive” pathway, leading to positive emotional responses and high satisfaction. In contrast, the eco-friendly experience of NEVs, through the enhancement of the sense of identity, primarily influences the consumers’ “affective” pathway. Although it gains moral recognition, it may lead to negative emotional responses and lower satisfaction in actual usage.

Additionally, the study confirms that the impact of functional experiences on emotional responses is moderated by perceived

usability. Specifically, perceived usability plays a crucial role in the emotional responses elicited by intelligent experience and eco-friendly experience. For intelligent experience, perceived usability moderates the effect of intelligent experience on the sense of efficiency. When consumers perceive the intelligent features of NEVs as easy to use, their sense of efficiency is significantly enhanced, triggering positive emotional responses and subsequently increasing consumer satisfaction. The high-tech attributes and convenience of the intelligent experience, through enhanced usability, elevate consumers' enjoyment and satisfaction during use, ultimately boosting overall satisfaction. Conversely, for eco-friendly experience, perceived usability moderates the effect of eco-friendly experience on the sense of identity. When consumers perceive the eco-friendly features of NEVs as easy to use, their sense of identity is strengthened, leading to more positive emotional responses. However, if the eco-friendly functional experience is perceived as difficult to operate or inconvenient, consumers' sense of identity and satisfaction are negatively impacted.

5.1 Theoretical contributions

Firstly, we employ a dual-path model to explore the impact of functional experiences on consumer satisfaction, and we identify emotional responses as the underlying mechanism through which functional experiences influence consumer satisfaction. In contrast to previous studies that rely solely on basic emotional responses to explain the effect of functional experiences on consumer satisfaction (Septianto et al., 2023), we incorporate emotional responses and perceived usability to develop a dual-path model integrating cognitively-oriented emotional responses (sense of efficiency) and affectively-oriented emotional responses (sense of identity). This theoretical framework allows us to validate that intelligent experience and eco-friendly experience elicit different emotional responses, leading to differential impacts on consumer satisfaction. Our findings provide a comprehensive perspective on the cognitive pathways of consumer satisfaction, contributing to a deeper understanding of the mechanisms underlying consumer satisfaction. This study offers new insights and methodologies for examining consumer satisfaction in the context of NEVs, enriching future academic research by serving as a valuable reference and promoting the advancement and refinement of consumer satisfaction theory.

Secondly, in classifying the functional experiences of new energy vehicles (NEVs), we identified two distinct functional attributes unique to NEVs and validated that both significantly impact consumer satisfaction. Unlike previous studies that analyzed the effect of singular, discrete functional experiences on consumer satisfaction (Lin et al., 2020; Li et al., 2023; Li and Shao, 2023), our research confirms the significant influence of intelligent experience and eco-friendly experience on consumer satisfaction. By systematically categorizing and studying functional experience variables, we not only extend existing research on the drivers of consumer satisfaction but also arrive at conclusions that differ from previous literature (Guo et al., 2021). Specifically, this study reveals the unique mechanisms through which intelligent experience and eco-friendly experience influence consumer satisfaction via cognitive and affective pathways, respectively, further advancing the application of the dual-path model in consumer behavior research.

Thirdly, in contrast to the perspective of previous research that solely considers perceived usability as a key determinant influencing consumer

satisfaction (Devaraj et al., 2002), this study, taking into account the complexity of consumer emotional responses, specifies the boundary conditions for the impact of the two types of functional experiences in NEVs on emotional reactions. The research findings indicate that the influence of functional experiences on consumer satisfaction is moderated by perceived usability. It provides a novel perspective to gain a deeper understanding of how consumers under the influence of the two types of functional experiences elicit positive emotional responses, thereby further enhancing our comprehension of consumer satisfaction.

5.2 Practical implications

The conclusions of this study have important guiding implications for the practical application of new energy vehicle enterprises.

Firstly, with NEVs maintaining the global lead in sales for eight consecutive years and an increasing number of consumers choosing them, this study confirms that higher levels of intelligent and environmental attributes contribute to increased consumer satisfaction and the achievement of higher levels of industrialization for NEVs. In the current context of new energy vehicle enterprises facing technological bottlenecks, it is challenging to significantly enhance the intelligent and environmental attributes of NEVs in the short term to meet the diverse needs of customers. Therefore, new energy vehicle enterprises should analyze their positioning and consumer characteristics, focusing on the hedonic value and experience of NEVs based on the perceived value of the majority of consumers purchasing NEVs. This targeted approach in the production of NEVs, whether emphasizing intelligent attributes or environmental attributes, will contribute to technological innovation and application, helping new energy vehicle enterprises enhance consumer satisfaction.

Secondly, this study provides marketing practitioners with valuable insights for designing and managing marketing activities. While many enterprises see functional experiences as an opportunity to promote NEVs or introduce functional experience appeals in advertisements to boost sales (Li et al., 2023), this study points out that different types of functional experiences evoke different emotional response mechanisms. Therefore, marketing practitioners should not merely highlight functional experiences but should distinguish between types of functional experiences, ensuring that the benefits of new energy vehicle products conveyed in marketing activities or advertisements match the different emotional response mechanisms of consumers.

Thirdly, with the development of the Internet and the rise of online review platforms, online reviews have become increasingly important for service-oriented enterprises. Taking appropriate intervention measures in the face of negative word-of-mouth can enhance consumer satisfaction (Xiong and Shu, 2023). This study, conducted in the context of NEV driving experiences, acknowledges the positive significance of NEVs, promoting the implementation of the "dual carbon" strategy, enhancing consumer satisfaction, and encouraging sustainable consumption behaviors. By deeply analyzing the different mechanisms through which intelligent experience and eco-friendly experience affect consumer satisfaction, this research provides specific strategic guidance for NEV enterprises. For example, during the design and marketing process, emphasis should be placed on improving the usability and entertainment value of intelligent features while optimizing the practicality and convenience of eco-friendly features. Additionally, companies should prioritize online review feedback,

promptly addressing and resolving negative consumer evaluations to enhance product and service experiences, thereby further boosting consumer trust and satisfaction in NEVs. These practical implications not only help NEV companies gain a competitive edge in the market but also provide crucial support for promoting green consumption and achieving sustainable development goals.

5.3 Research limitations and future prospects

Firstly, as an exploratory study, this research only tested Chinese consumers as the sample. Although the hypotheses proposed in this paper have been verified, the holistic thinking pattern of Chinese people has an impact on their cognitive processes. Due to space limitations, this study did not conduct empirical tests on Western consumers. It is speculated that if Western consumers are used as samples, due to their emphasis on individual and categorical analytical thinking rather than holistic and relational thinking, they may activate either the “rational” or “emotional” cognitive paths separately when facing different types of functional experiences, thus eliciting corresponding emotional responses (Bai et al., 2024). Future research can further examine this issue from the perspective of cognitive differences between Eastern and Western cultures.

Secondly, this study only focused on consumer satisfaction with NEVs and used new energy vehicle ratings as a measure of consumer satisfaction, which is consistent with previous research methods (Wu and Huo, 2023). Future research can use methods such as observation or in-depth interviews to gain a deeper understanding of consumers' driving experiences with NEVs, such as whether the intelligent assisted driving of NEVs affects consumers' perception of the value of these vehicles.

Thirdly, the text analysis method used in the study has limitations. Due to the lack of mature studies defining words related to intelligence and environmental aspects, and the absence of dictionaries containing words with different emotional polarities, it is challenging to quantify the degree of intelligent and environmental attributes of NEVs. Future research can develop dictionaries based on online text that include words with different emotional polarities and are more effective.

References

- Alalwan, A. A. (2020). Mobile food ordering apps: an empirical study of the factors affecting customer e-satisfaction and continued intention to reuse. *Int. J. Inf. Manag.* 50, 28–44. doi: 10.1016/j.jinfomgt.2019.04.008
- Bai, S., Yu, D., Han, C., Yang, M., Gupta, B. B., Arya, V., et al. (2024). Warmth trumps competence? Uncovering the influence of multimodal Ai anthropomorphic interaction experience on intelligent service evaluation: insights from the high-evoked automated social presence. *Technol. Forecast. Soc. Chang.* 204:123395. doi: 10.1016/j.techfore.2024.123395
- Belanche, D., Casaló, L. V., Schepers, J., and Flavián, C. (2021). Examining the effects of robots' physical appearance, warmth, and competence in frontline services: the humanness-value-loyalty model. *Psychol. Mark.* 38, 2357–2376. doi: 10.1002/mar.21532
- Berger, J. (2011). Arousal increases social transmission of information. *Psychol. Sci.* 22, 891–893. doi: 10.1177/0956797611413294
- Berger, J., Humphreys, A., Ludwig, S., Moe, W. W., Netze, O., Schweidel, D. A., et al. (2020). Uniting the tribes: using text for marketing insight. *J. Mark.* 84, 1–25. doi: 10.1177/0022242919873106
- Bockarjova, M., and Steg, L. (2014). Can protection motivation theory predict pro-environmental behavior? Explaining the adoption of electric vehicles in the Netherlands. *Glob. Environ. Chang.* 28, 276–288. doi: 10.1016/j.gloenvcha.2014.06.010
- Borghi, M., Mariani, M. M., Vega, R. P., and Wirtz, J. (2023). The impact of service robots on customer satisfaction online ratings: the moderating effects of rapport and contextual review factors. *Psychol. Mark.* 40, 2355–2369. doi: 10.1002/mar.21903
- Carter, T. J., and Gilovich, T. (2012). I am what I do, not what I have: the differential centrality of experiential and material purchases to the self. *J. Pers. Soc. Psychol.* 102, 1304–1317. doi: 10.1037/a0027407
- Cheng, Y. W., Chen, J., and Lin, K. (2015). Exploring consumer attitudes and public opinions on battery electric vehicles. *Journal of Renewable and Sustainable Energy* 7:043122. doi: 10.1063/1.4926772
- Chuah, S. H. W., Aw, E. C. X., and Yee, D. (2021). Unveiling the complexity of consumers' intention to use service robots: an fsqca approach. *Comput. Hum. Behav.* 123:106870. doi: 10.1016/j.chb.2021.106870
- Cronin, J. J., Brady, M. K., and Hult, G. T. M. (2000). Assessing the effects of quality, value, and customer satisfaction on consumer behavioral intentions in service environments. *J. Retail.* 76, 193–218. doi: 10.1016/S0022-4359(00)00028-2
- Cui, Q., Wang, Y., Chen, K. C., Ni, W., Lin, I.-C., Tao, X., et al. (2019). Big data analytics and network calculus enabling intelligent management of autonomous vehicles in a smart city. *IEEE Internet Things J.* 6, 2021–2034. doi: 10.1109/JIOT.2018.2872442

Data availability statement

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

Author contributions

SB: Writing – review & editing, Supervision, Resources, Methodology, Funding acquisition. TS: Writing – original draft, Visualization, Validation, Software, Investigation, Data curation. HH: Writing – review & editing, Visualization, Supervision, Project administration, Data curation, Conceptualization.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. We appreciate the financial support of the Natural Science Foundation of Heilongjiang Province (Grant No. LH2022G014) and the Social Science Foundation of Heilongjiang Province (Grant No. 22GLD356).

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q.* 13:319. doi: 10.2307/249008
- De Guinea, A. O., Titah, R., and Léger, P. M. (2014). Explicit and implicit antecedents of users' behavioral beliefs in information systems: a neuropsychological investigation. *J. Manag. Inf. Syst.* 30, 179–210. doi: 10.2753/MIS0742-1222300407
- Devaraj, S., Fan, M., and Kohli, R. (2002). Antecedents of B2C channel satisfaction and preference: validating e-commerce metrics. *Inf. Syst. Res.* 13, 316–333. doi: 10.1287/isre.13.3.316.77
- Fan, W., and Wang, Q. (2022). A study on the impact of personalized intelligent recommendation on consumers' online impulse purchase intention. *Manag. Rev.* 34, 146–156+194. doi: 10.14120/j.cnki.cn11-5057/f.2022.12.003
- Fei, X. Z., Huang, X., and Wang, Y. W. (2021). Does awe make people obedient? --on the persuasive role of awe on individuals. *Nankai Bus. Rev.* 24, 1–24.
- Fritzsche, I., and Häfner, K. (2012). The malicious effects of existential threat on motivation to protect the natural environment and the role of environmental identity as a moderator. *Environ. Behav.* 44, 570–590. doi: 10.1177/0013916510397759
- Gao, H., Yu, H., Xie, G., Ma, H., Xu, Y., and Li, D. (2019). Hardware and software architecture of intelligent vehicles and road verification in typical traffic scenarios. *IET Intell. Transp. Syst.* 13, 960–966. doi: 10.1049/iet-its.2018.5351
- Gefen, D., Karahanna, E., and Straub, D. W. (2003). Trust and tam in online shopping: an integrated model. *MIS Q.* 27:51. doi: 10.2307/30036519
- González-Mansilla, Ó., Berenguer-Contró, G., and Serra-Cantalops, A. (2019). The impact of value co-creation on hotel brand equity and customer satisfaction. *Tour. Manag.* 75, 51–65. doi: 10.1016/j.tourman.2019.04.024
- Gulzari, A., Wang, Y., and Prybutok, V. (2022). A green experience with eco-friendly cars: a young consumer electric vehicle rental behavioral model. *J. Retail. Consum. Serv.* 65:102877. doi: 10.1016/j.jretconser.2021.102877
- Guo, X. S., Zhang, Y., and Xu, J. (2021). The effects of apology commitment-type management feedback strategies on customers' secondary satisfaction - based on customers' diverse emotion moderation effects. *Chinese J. Manag. Sci.* 29, 217–227. doi: 10.16381/j.cnki.issn1003-207x.2021.02.023
- Heinen, S., Botha, A., Head, D., Rafferty, P., and Pieter, R. (2023). Customer-centric electric vehicle orchestration in New Zealand: how residential smart charging can deliver affordability and customer satisfaction. *IEEE Power Energy Magaz.* 21, 38–47. doi: 10.1109/MPE.2023.3308250
- Hong, J. C., Lin, P. H., and Hsieh, P. C. (2017). The effect of consumer innovativeness on perceived value and continuance intention to use smartwatch. *Comput. Hum. Behav.* 67, 264–272. doi: 10.1016/j.chb.2016.11.001
- Kim, J., and Park, E. (2019). Beyond coolness: predicting the technology adoption of interactive wearable devices. *J. Retail. Consum. Serv.* 49, 114–119. doi: 10.1016/j.jretconser.2019.03.013
- Kumar, A., Chakraborty, S., and Bala, P. K. (2023). Text mining approach to explore determinants of grocery mobile app satisfaction using online customer reviews. *J. Retail. Consum. Serv.* 73:103363. doi: 10.1016/j.jretconser.2023.103363
- Kunkel, T., Lock, D., and Doyle, J. P. (2021). Gamification via mobile applications: a longitudinal examination of its impact on attitudinal loyalty and behavior toward a core service. *Psychol. Mark.* 38, 948–964. doi: 10.1002/mar.21467
- Lee, W., Xiong, L., and Hu, C. (2012). The effect of facebook users' arousal and valence on intention to go to the festival: applying an extension of the technology acceptance model. *Int. J. Hosp. Manag.* 31, 819–827. doi: 10.1016/j.ijhm.2011.09.018
- Li, K., Chen, T., Luo, Y., and Wang, J. (2012). Intelligent environment-friendly vehicles: concept and case studies. *IEEE Trans. Intell. Transp. Syst.* 13, 318–328. doi: 10.1109/TITS.2011.2170680
- Li, C., Niu, Y., and Wang, L. (2023). How to win the green market? Exploring the satisfaction and sentiment of Chinese consumers based on text mining. *Comput. Hum. Behav.* 148:107890. doi: 10.1016/j.chb.2023.107890
- Li, Y., Ouyang, K., Li, N., Rahmani, R., Yang, H., Pei, Y., et al. (2020). A blockchain-assisted intelligent transportation system promoting data services with privacy protection. *Sensors* 20:2483. doi: 10.3390/s20092483
- Li, W. C., and Shao, J. (2023). A study on the influencing factors of consumers' eco-friendly apparel purchasing behavior - based on the theory of planned behavior and norm activation theory. *Chinese J. Manag. Sci.* 26, 1–20. doi: 10.16381/j.cnki.issn1003-207x.2022.0070
- Li, J. Z., Zhang, G. P., Liu, C. L., Sun, B., and Wang, Y. (2023). Analysis of optimal control decision of new energy automobile enterprises based on low-carbon and intelligent advertisement positioning. *Chinese J. Manag. Sci.* 39, 1–11. doi: 10.16381/j.cnki.issn1003-207x.2022-2359
- Lin, H., Zhang, M., and Gursoy, D. (2020). Impact of nonverbal customer-to-customer interactions on customer satisfaction and loyalty intentions. *Int. J. Contemp. Hosp. Manag.* 32, 1967–1985. doi: 10.1108/IJCHM-08-2019-0694
- Liu, Z., and Park, S. (2015). What makes a useful online review? Implication for travel product websites. *Tour. Manag.* 47, 140–151. doi: 10.1016/j.tourman.2014.09.020
- Liu, Y. Q., Song, Z. Y., Gao, H. W., and Feng, R. (2023). A 10-year study on the promotion effect of new energy vehicles in China: a spatial effect perspective. *Manag. Rev.* 35, 3–16. doi: 10.14120/j.cnki.cn11-5057/f.2023.03.027
- Mano, H., and Oliver, R. L. (1993). Assessing the dimensionality and structure of the consumption experience: evaluation, feeling, and satisfaction. *J. Consum. Res.* 20:451. doi: 10.1086/209361
- Partala, T., and Saari, T. (2015). Understanding the most influential user experiences in successful and unsuccessful technology adoptions. *Comput. Hum. Behav.* 53, 381–395. doi: 10.1016/j.chb.2015.07.012
- Pelegrín-Borondo, J., Reinares-Lara, E., and Olarte-Pascual, C. (2017). Assessing the acceptance of technological implants (the cyborg): evidences and challenges. *Comput. Hum. Behav.* 70, 104–112. doi: 10.1016/j.chb.2016.12.063
- Peng, T., Yang, X., Xu, Z., Liang, Y. (2020). Constructing an environmental friendly low-carbon-emission intelligent transportation system based on big data and machine learning methods. *Sustain. For.* 12:8118. doi: 10.3390/su12198118
- Prebensen, N. K., and Xie, J. (2017). Efficacy of co-creation and mastering on perceived value and satisfaction in tourists' consumption. *Tour. Manag.* 60, 166–176. doi: 10.1016/j.tourman.2016.12.001
- Qiao, S., Yao, T., Wang, N., Cao, H., and Yi, M. (2023). "Outward observation" and "introspection": a study of green consumption willingness triggered by environmental threats: a dual-path model based on moral emotions. *Nankai Bus. Rev.* 27, 1–33.
- Ramón, B. B. (2023). Identifying the attributes of consumer experience in Michelin-starred restaurants: a text-mining analysis of online customer reviews. *Br. Food J.* 125, 579–598. doi: 10.1108/Bfj-05-2023-0408
- Septianto, F., Seo, Y., Li, L. P., and Shid, L. (2023). Awe in advertising: the mediating role of an abstract mindset. *J. Advert.* 52, 24–38. doi: 10.1080/00913367.2021.1931578
- Sun, S., Law, R., and Schuckert, M. (2020). Mediating effects of attitude, subjective norms and perceived behavioural control for mobile payment-based hotel reservations. *Int. J. Hosp. Manag.* 84:102331. doi: 10.1016/j.ijhm.2019.102331
- Thompson, D. V., Hamilton, R. W., and Rust, R. T. (2005). Feature fatigue: when product capabilities become too much of a good thing. *J. Mark. Res.* 42, 431–442. doi: 10.1509/jmk.2005.42.4.431
- Tsui, E., Wang, W. M., Cheung, C. F., and Lau, A. S. M. (2010). A concept-relationship acquisition and inference approach for hierarchical taxonomy construction from tags. *Inf. Process. Manag.* 46, 44–57. doi: 10.1016/j.ipm.2009.05.009
- Wang, Y. D., Yang, Q., Zhu, J. J., and Liu, R. (2023). The effect of marketing orientation on consumer regret in overconsumption: the mediating role of responsibility attribution and the moderating role of self-control. *J. Ind. Eng.* 37, 46–56. doi: 10.13587/j.cnki.jieem.2023.06.005
- Wang, Q., Zhang, W., Li, J., Mai, F., and Ma, Z. (2022). Effect of online review sentiment on product sales: the moderating role of review credibility perception. *Comput. Hum. Behav.* 133:107272. doi: 10.1016/j.chb.2022.107272
- Wei, Y., Donthu, N., and Bernhardt, K. L. (2013). Effects of cognitive age, dispositional time perceptions, and time view manipulations on product attribute evaluations. *J. Bus. Res.* 66, 2171–2177. doi: 10.1016/j.jbusres.2012.01.008
- Whitehead, J. C., and Wicker, P. (2018). Estimating willingness to pay for a cycling event using a willingness to travel approach. *Tour. Manag.* 65, 160–169. doi: 10.1016/j.tourman.2017.09.023
- Wolf, A., and Seebauer, S. (2014). Technology adoption of electric bicycles: a survey among early adopters. *Transp. Res. A Policy Pract.* 69, 196–211. doi: 10.1016/j.tra.2014.08.007
- Wu, X., and Huo, Y. (2023). Impact of the introduction of service robots on consumer satisfaction: empirical evidence from hotels. *Technol. Forecast. Soc. Change.* 194. doi: 10.1016/j.techfore.2023.122718
- Xiong, Y. Q., and Shu, N. X. (2023). Negative word-of-mouth, interventions and consumer purchase intention of new energy vehicles. *Chinese J. Manag. Sci.* 39, 1–13. doi: 10.16381/j.cnki.issn1003-207x.2022.0470
- Xu, Y., and Guo, W. J. (2023). A dual perspective of uncertainty-an exploration based on blind box sales. *J. Manag. Sci.* 36, 119–131.
- Yang, M., and Qiao, W. R. H. (2023). A study on the impact of brand co-branded product attributes on consumers' purchase intention--based on the perspective of consumers' perceived value. *China Acad. J. Electr. Publish. House* 42, 201–212.
- Yang, K., Zhang, Q., Yu, L., and Pan, X. (2023). A study of new energy vehicle purchase intention and boosting policy based on consumer values and limited rationality. *Manag. Rev.* 35, 146–158. doi: 10.14120/j.cnki.cn11-5057/f.2023.01.008
- Yu, C. E. (2020). Humanlike robots as employees in the hotel industry: thematic content analysis of online reviews. *J. Hosp. Market. Manag.* 29, 22–38. doi: 10.1080/19368623.2019.1592733
- Zhang, X. F., Song, G., and Yan, Y. (2020). Research on the impact of urban low-carbon transportation system on energy consumption structure - panel data experience from fourteen Chinese cities. *Chinese J. Manag. Sci.* 28, 173–183. doi: 10.16381/j.cnki.issn1003-207x.2020.12.017



OPEN ACCESS

EDITED BY

Christian Andreas Klöckner,
NTNU, Norway

REVIEWED BY

Katinka J. P. Quintelier,
VU Amsterdam, Netherlands
Tobias Otterbring,
University of Agder, Norway

*CORRESPONDENCE

Anna Schorn

✉ a.schorn@ikmz.uzh.ch

RECEIVED 10 April 2024

ACCEPTED 13 August 2024

PUBLISHED 11 September 2024

CITATION

Schorn A (2024) Why should I when no one else does? A review of social norm appeals to promote sustainable minority behavior. *Front. Psychol.* 15:1415529. doi: 10.3389/fpsyg.2024.1415529

COPYRIGHT

© 2024 Schorn. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Why should I when no one else does? A review of social norm appeals to promote sustainable minority behavior

Anna Schorn*

Department of Communication and Media Research, University of Zurich, Zürich, Switzerland

Social norm appeals have been proven successful in promoting sustainable behavior that most people engage in. However, research on the effectiveness of social norm appeals in promoting sustainable behavior performed by a numerical minority of people is lacking. This systematic review aimed to examine empirical studies that applied social norm appeals and to elaborate on how social norm appeals could be effectively designed to foster sustainable minority behaviors. Thirty-six articles, including 54 studies, applying social norm interventions to promote sustainable minority behavior were compiled and discussed, with a particular focus on the methodology and operationalization of social norm appeals. The results showed that static descriptive minority social norm appeals might not be effective in promoting sustainable behavior. Nevertheless, there appeared to be differences depending on the strength of the norm and the environmental attitudes of the population. However, using injunctive and dynamic descriptive social norm appeals appear promising approaches because these appeals are less prone to undesirable effects. Nevertheless, it could be problematic if injunctive and descriptive social norm appeals are not aligned, but results are inconclusive. For practitioners, emphasizing social change and highlighting majority approval are simple, low-cost strategies with great potential to induce compliance and encourage sustainable minority behavior without running the risk of backfire effects.

KEYWORDS

minority behavior, nudging, social norm appeals, sustainability, social norms, social change, backfire effects, environmental psychology

Introduction

Mitigating the climate crisis is a global challenge facing all individuals, nations, and economic sectors (United Nations, 2015). Despite international arrangements, such as the Paris Agreement to combat climate change and its negative impacts, anthropocentric contributions to greenhouse gas emissions are far beyond the defined targets (Fell and Traber, 2020; IPCC, 2021). Households are estimated to be responsible for up to 72% of global emissions (Hertwich and Peters, 2009). Therefore, changing individual consumption behavior remains a critical, contemporary ambition (Fell and Traber, 2020).

In behavioral sciences, one of the most important interventions to change behavior in general and to motivate sustainable behavior in particular is the use of social norm appeals (Rhodes et al., 2020; Cialdini and Jacobson, 2021). Social norm interventions can be subtle, simple, low-cost, and effective ways to encourage compliance (Mortensen et al., 2019; Rhodes et al., 2020). Social norm appeals attempt to change behavior by modifying the

prevailing view that a particular behavior is more prevalent or has gained wide approval in a certain social context (Mortensen et al., 2019; Rhodes et al., 2020; Cialdini and Jacobson, 2021).

According to the focus theory of normative conduct, descriptive social norm appeals (DSNAs) provide information about the proportion of people who engage in the target behavior, while injunctive social norm appeals (ISNAs) describe the proportion of people approving of the behavior within a reference group (Cialdini et al., 1991; Goldstein et al., 2008; Schultz et al., 2007). Several meta-analyses have shown that both types of social norm appeals are effective in promoting sustainable behavior when implemented and approved by a numerical majority of people (Cialdini et al., 1991; Abrahamse and Steg, 2013; Poškus, 2016; Farrow et al., 2017; Rhodes et al., 2020).

However, measures to protect the environment and sustainable habits are often new behaviors that may only be exhibited initially by a numerical minority of people (e.g., Brechin and Bhandari, 2011; European Commission, 2020, 2021; Passafaro, 2020; de Groot, 2022). When the targeted behavior is not prevalent, DSNAs run the risk of undesirable boomerang or backfire effects when people learn that their (undesirable) behavior is the norm (Reno et al., 1993; Loschelder et al., 2019). In this case, normative information can produce the opposite of what a communicator intends (Cialdini, 2003; Schultz et al., 2007; Richter et al., 2018; Berger, 2021). However, recent studies have used dynamic DSNAs to present behavior as a growing trend that more and more people are following to prevent such undesirable effects (Sparkman and Walton, 2017; Mortensen et al., 2019).

At the same time, environmental issues have received increasing attention in politics and the mass media, and different studies have shown a high awareness of climate change in large parts of the world population (Brechin and Bhandari, 2011; Lee et al., 2015; Baiardi and Morana, 2021; Andre et al., 2024). Most people see climate change and sustainability as important problems, and the majority appear to have realized that something must be done to protect the environment (Baiardi and Morana, 2021; Economist Intelligence Unit, 2021; Andre et al., 2024). Therefore, people seem to approve of sustainable behavior in general and of specific actions, but they do not yet adapt their own behavior to the same extent. Thus, the initial situation for new sustainable behaviors would often include a collective injunctive majority social norm (most people approve of sustainable behaviors) and a collective descriptive minority social norm (only a few people engage in the behavior).

Given these circumstances, the purpose of the present research was to determine how social norm appeals can be used effectively to activate social norms with the aim of promoting sustainable behaviors performed by a numerical minority of people. To do so, this systematic review investigated previous empirical studies that applied social norm appeals to promote sustainable minority behaviors and elaborates on how they could be effectively designed to foster sustainable minority behaviors. Several reviews and meta-analyses have already focused on social norm interventions in general (Rimal and Lapinski, 2015; Chung and Rimal, 2016; Legros and Cislighi, 2020; Lutkenhaus et al., 2023) and to promote environment-friendly behaviors (Bergquist et al., 2020; Miller and Prentice, 2016; Poškus, 2016; Farrow et al., 2017; Yamin

et al., 2019; Rhodes et al., 2020; Saracevic and Schlegelmilch, 2021; Helferich et al., 2023). However, they did not explicitly focus on minority behaviors which is why the results have only limited applicability within the context of sustainability specifically. Moreover, this literature review provides a qualitative focus and discussion of methodological variances which complements meta-analytical studies. Since there is great variability in the study designs, a narrative review can be particularly useful because the existing studies are not homogeneous in terms of design, measures, participants, interventions, control groups and outcomes. If these differences are taken into account, only little studies remain that can be meaningfully compared with each other due to a similar design. In addition, in the context of minority behavior, the state of research suggests that such interventions may be ineffective, which is why it is enriching to discuss under which exact circumstances social norm appeals can be used effectively in the context of minority behavior or not. Complementary to other narrative reviews that provide informal information for practitioners and policymakers (Sparkman et al., 2020a) or a concise, outcome-oriented research overview (Cialdini and Jacobson, 2021), this review compares and discusses the methods and operationalizations with regard to the respective results.

Theoretical background

The idea that the behavior of individuals is influenced by the behavior of their social group has a long tradition in research (Fishbein and Ajzen, 1975; Schwartz, 1973; Sherif, 1936). However, social influence research has entered a new era with the research on social norms by Cialdini et al., whose focus theory of normative conduct is based on the premise that social norms powerfully and systematically influence human behavior (Cialdini et al., 1990, 1991). According to the theory, there are descriptive norms that reflect the typical or normal behavior of people and injunctive norms that reflect what behavior is commonly desirable or approved (Cialdini et al., 1991). Descriptive norms can influence behavior based on social proof because they indicate behavior that has proven to be effective for others (Jacobson et al., 2020). Injunctive norms can influence behavior by creating social pressure to conform because they show what behavior a social group approves or expects. According to focus theory, individuals conform to the focal or salient norm even when other types of norms dictate a behavior contrary to the target behavior (Cialdini et al., 1991). This means that social norms can be activated or made salient through social norm appeals so that they can serve as guides for behavioral decisions.

Descriptive social norm appeals

Descriptive social norms refer to what other people do or the behaviors they engage in. Typically, they characterize the perception of what most people do within a reference group (Cialdini et al., 1991). Descriptive norms can be used by individuals as evidence of how (most) people behave and, therefore, of what will likely be effective behavior in a certain

context. In this way, descriptive norms work heuristically as shortcuts when people imitate what most people do because that is likely to be effective for a given situation (Cialdini et al., 1990).

To modify the perceived descriptive norms, DSNAs indicate how high the frequency of occurrence of a target behavior is within a certain reference group (e.g., “Nearly 25% of guests choose to reuse their towels each day”). However, when individuals learn that only a small number of people engage in the target behavior, this cannot serve as social proof and should not encourage compliance. In this case, DSNAs can lead to backfire effects that suppress the target behavior.

Within DSNAs, a further distinction can be made between static and dynamic DSNAs. Static DSNAs report the proportion of people currently performing the behavior, while dynamic DSNAs highlight trends and social change (Sparkman and Walton, 2017; Mortensen et al., 2019). Dynamic DSNAs are specifically studied in the context of minority behavior because they can prevent the undesirable effects of static DSNAs that often occur in the context of sustainable behavior.

Injunctive social norm appeals

Injunctive social norms constitute the moral rules of a group and motivate actions by promising social rewards or creating a fear of social sanctions for them (Cialdini et al., 1991). However, people systematically underestimate the approval of different environmental behaviors in the population and have a misperception of injunctive norms (Nolan, 2021; Wolf et al., 2023; Andre et al., 2024). ISNAs can adjust these misperceptions and increase perceived injunctive norms (e.g., “85% of the student sample approves of other students who engage in energy conservation”). However, when looking at ISNAs, it is evident that they are not consistently defined and applied (Shulman et al., 2017; Schorn et al., 2023).

In experimental studies, some authors used ISNAs that stated directly what behavior should be performed with regard to a reference group (prescriptive ISNAs; Melnyk et al., 2013; White and Simpson, 2013; He et al., 2019), while others only referred to whether the behavior had the approval of the reference group (approving ISNAs; Smith and Louis, 2008; de Groot and Schuitema, 2012; Smith et al., 2012; Bonan et al., 2020; Ge et al., 2020; Schorn and Wirth, 2023). In some studies, an ISNA was simply an appeal directing people on what to do (e.g., “Choose a sustainable cup!”) (Mollen et al., 2013; Bergquist and Nilsson, 2019; Loschelder et al., 2019; Poškus et al., 2019). However, these appeals made without a reference group should not be considered ISNAs because they might not have activated the perceived injunctive norms, as the norm was not directly stated (cf. Cialdini and Jacobson, 2021). Therefore, they may not build up social pressure or the fear of social sanctions but rather activate the moral obligation to act environmentally friendly.

Overall, majority ISNAs seem to be suitable for promoting environment-friendly behavior (Rhodes et al., 2020). Nevertheless, due to the described methodological differences, it is important to look closely at the operationalization of ISNAs if their effectiveness

is to be assessed, particularly in the context of minority behavior. Moreover, the few studies investigating ISNAs in the context of minority behavior typically include not only ISNAs but also DSNAs (Schultz et al., 2008; de Groot and Schuitema, 2012; Smith et al., 2012). Therefore, this interaction of ISNAs and DSNAs must be considered when researching sustainable behaviors.

Conflicting social norm appeals

Individuals often have prevalent positive attitudes on environmental topics and seem to approve of sustainable behavior and specific actions, but they do not adapt their own behavior to the same extent (European Commission, 2020; Baiardi and Morana, 2021; Economist Intelligence Unit, 2021). For example, around 90% of Europeans stated that people should be educated on how to behave more sustainably and that authorities and industry should make greater efforts to reduce plastic waste, but only one-third of the respondents avoided buying over-packaged products (European Commission, 2020). Such attitude-behavior gaps indicate conflicting social norms on a higher level because most people seem to approve of sustainable behaviors, but due to different barriers, only a small number of people adopt the corresponding behaviors (cf. Gifford, 2011; Lacroix et al., 2019). Thus, the initial situation for sustainable behaviors can involve a collective injunctive majority but a descriptive minority social norm.

In the context of sustainable behavior, it is therefore important to not only compare DSNAs and ISNAs but also investigate how different social norm appeals influence each other. People could experience an inner conflict or cognitive dissonance that could suppress the desired behavior when they experience that the usual behavior does not correspond to what should be done (cf. Thøgersen, 2008; Bonan et al., 2020; Jacobson et al., 2020). Accordingly, research on social norm conflict has argued that it can be counterproductive if ISNAs do not match DSNAs, and vice versa (Smith et al., 2012; Ge et al., 2020). However, in this context, there are again differences in the way the studies were conducted and it is important to consider exactly which operationalization the researchers used to arrive at which result.

Materials and methods

This study aimed to determine how social norm appeals can be used effectively for promoting sustainable minority behavior. To do so, empirical studies investigating effects of social norm appeals were reviewed. Survey-only studies were not included because they generally did not involve social norm appeals or interventions and only measured perceived social norms. To make the results comparable, the social norm message should state that the promoted behavior is performed by a numerical minority of people within a reference group in a static or dynamic component, either numerically or in words referring to a share. This is because social norm appeals may affect persuasive outcomes due to a change in the projected commonness of behavior (Sparkman and Walton, 2017; Loschelder et al., 2019; Mortensen et al., 2019). Other

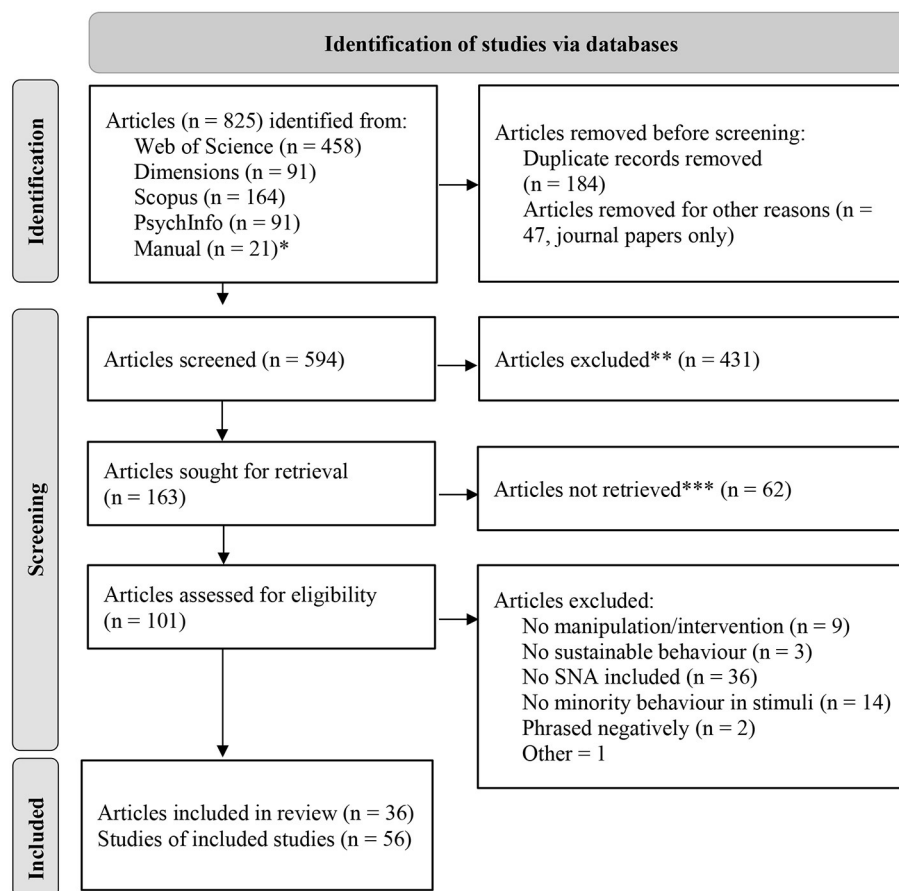


FIGURE 1

PRISMA 2020 flow diagram for new systematic reviews (Page et al., 2021). *The manually added articles also include new studies that were published during the review and publication process and were added subsequently. **Articles from journals not relevant to the topic have been excluded (e.g., biological journals, zoology, animal research, health journals etc.). ***The title was a strong indicator that (1) the study did not address sustainable behavior, (2) the study did not address minority behavior, (3) there was no intervention or manipulation of minority descriptive, injunctive, or both types of SNAs (experimental study), or (4) the message did not state that the promoted behavior or attitude was held by a minority in a dynamic or static component. (5) The SNA was phrased negatively.

normative messages may not affect perceived social norms and thus operate differently (Poškus et al., 2019). Therefore, studies in which social norm appeals were formulated negatively were also excluded. Consequently, the following criteria were used to decide whether a study would be included in the analysis:

- The aim of the study was to promote sustainable behaviors or attitudes.
- The promoted behavior was performed by a numerical minority of people (< 50%) within a reference group (minority behavior).
- There was an intervention or manipulation of minority descriptive, injunctive, or both types of social norm appeals (experimental study).
- The message verbally stated in a social norm appeal that the promoted behavior was performed by a numerical minority of people in a static or dynamic component (social norm appeal).
- The social norm appeal was phrased positively. The focus must be on the minority performing the target behavior and not on the majority *not* performing the behavior.

Various databases were searched (e.g., Web of Science, Scopus, Dimensions, and PsychInfo) using the following search string: [(environmentally friendly) OR (green consumption) OR (environmental) OR (conservation) OR (environmentally-friendly) OR (sustainable)] AND [(injunctive OR descriptive OR trending OR dynamic) AND (norm)] AND (experiment OR intervention) NOT (survey) in the abstracts, titles, and keywords. The references of the included articles were also searched for additional studies. The process from identification to inclusion is summarized in the PRISMA diagram (Page et al., 2021; see Figure 1).

Results

Following this procedure, 36 articles, including 54 studies, using social norm appeals were identified (Table A1). The articles were published between 2007 and 2024, with 24 published in the last five years, demonstrating that this is a novel and steadily growing field. In the following, a descriptive overview of the

individual studies included in the papers will be provided before the results are reviewed and discussed with regard to the effects.

Descriptive overview

The majority of studies were (online) experiments (>78%) but the proportion of field experiments was also relatively high at approximately 20%. Most studies were conducted in North America (~46%) and Europe (~43%), whereas only a few were conducted in other parts of the world. The studies were mainly in the areas of sustainable diet (>36%), followed by energy and water conservation (14%), sustainable consumption (14%), waste prevention (9%), voluntary carbon offsets (7%) and transportation (5%). Most studies focusing on minority behavior referred to descriptive norms and DSNAs, whereas only a few studies examined different characteristics of ISNAs (Schultz et al., 2008; de Groot and Schuitema, 2012; Smith et al., 2012; Lalot et al., 2018, 2019). Most studies focused on dynamic DSNAs and compared them vs. a control group (~29%) or a static DSNAs (~27%). More than a third of the studies contrasted minority with majority behavior (~36%) and few studies compared the strength of different minority DSNAs. Moreover, the studies differed in their dependent variables: Field experiments typically observed actual behavior (e.g., Berger, 2021; Loschelder et al., 2019; study 1; Richter et al., 2018), while lab and online experiments typically measured behavioral intentions (e.g., Smith et al., 2012; Aldoh et al., 2021; de Groot et al., 2021; Aruta, 2022) or the interest in the behavior (e.g., Sparkman and Walton, 2017). Moreover, some of the studies measured effects on perceived social norms (e.g., Lapinski et al., 2017; Reynolds-Tylus et al., 2019). In contrast to the field experiments, additional variables were often measured in the online experiments, which is beneficial if the mechanisms of action of social norm appeals are considered (e.g., Sparkman et al., 2020b). Most studies have used student or convenience samples and only a few studies have worked with quasi-representative samples, which is partly due to the reference groups used (see Table A1).

Procedure

The review process followed three steps. First, the articles were reviewed inductively for commonalities and differences, with a particular focus on methodology and operationalization. Based on this initial assessment of the current state of research, various categories were determined in the second step to which the research questions and findings from the articles could be assigned. These categories were the basis for developing the guiding questions that were explicitly or implicitly addressed in the articles. For example, some of the questions were not directly examined in the studies, but they were raised in the discussion of the respective articles. Therefore, the formulation of such guiding questions was important to relate the studies to each other and to discuss the results accordingly.

Overall, six guiding questions were identified in this initial screening. Studies applying minority DSNAs raised the questions of whether there were differences in the effect depending on the

strength of the social norm appeal (Q1) or sample characteristics (Q2) and under which circumstances they may lead to backfire effects (Q3). Studies using dynamic DSNAs examined whether such negative effects caused by static DSNAs could be prevented by highlighting a trend in behavior (Q4). Studies applying ISNAs have raised the question of whether their effect was also influenced by the strength of the social norm appeal (Q5). Studies using descriptive and ISNAs, which could be either congruent or conflicting, raised the question of how this alignment affected their impact (Q6). In the third step, the results of the studies were compiled and compared with reference to these guiding questions.

Effects of descriptive minority social norm appeals

There are various studies on the effects of minority DSNAs (see Table A1). On the one hand, experiments examine whether there are differences on persuasive outcomes depending on the strength of (majority and minority) DSNAs (Q1). Among these, there are studies that suggest that the effects differ depending on the environmental dispositions of the participants (Q2), which can also be decisive for the occurrence of backfire effects (Q3). On the other hand, many experiments compare dynamic DSNAs against either static DSNAs or a control group without DSNAs (Q4).

Q1: How do the effects of static descriptive social norm appeals depend on the strength of the social norm appeal?

In their early research on DSNAs, Demarque et al. (2015) found that both descriptive majority (70%) and minority DSNAs (9%) increased the number of ecological products sold. However, their second experiment with a different population confirmed these results only for majority DSNAs (<50%). Similar to the latter result, Aruta (2022) showed that minority DSNAs are less effective than majority DSNAs. Furthermore, Aldoh et al. (2021), Berger (2021), Loschelder et al. (2019), Mortensen et al. (2019), Richter et al. (2018), Schorn and Wirth (2023, 2024), Shealy et al. (2018), and Sparkman and Walton (2017) concluded that static minority DSNAs did not have positive effects compared with the control groups. Moreover, Lapinski et al. (2017) showed that a minority DSNA (3%) lowered the perceived prevalence of the behavior compared with a majority DSNA (90%), which in turn lowered the behavioral intention but not the attitude toward the behavior. Similarly, Reynolds-Tylus et al. (2019) revealed that a minority DSNA (27%/32%) lowered the perceived prevalence of the behavior compared with a majority DSNA (73%/68%), which also lowered behavioral intention. However, neither Lapinski et al. (2017) nor Reynolds-Tylus et al. (2019) reported direct effects on persuasive outcomes.

Overall, minority DSNAs do not seem to be effective in promoting sustainable behavior, regardless of their strength. Some of the reviewed studies even indicated that the use of minority DSNAs could backfire, meaning that the minority DSNAs performed worse than the control groups without any normative information (Schultz et al., 2007; Richter et al., 2018; Mortensen

et al., 2019; Berger, 2021). However, six of the reviewed articles concluded, either explicitly or implicitly, that there may have been differences in the effects of minority DSNAs due to sample characteristics, which could be a crucial factor when analyzing the effects of social norm appeals.

Q2: How do the effects of static descriptive minority social norm appeals depend on sample characteristics?

Demarque et al. (2015) attributed the varying results in different studies to the fact that samples with different characteristics were used (general population of university students vs. business students). In their first lab experiment, they did not find differences between a minority DSN and a majority DSN. Therefore, the strength of the DSN was further differentiated in their second experiment (1%, 9%, 70%, and 90%). In contrast to the first experiment, consumers in the majority conditions (>50%) bought and spent more money on green products than those in the minority conditions (<50%). Due to the sample differences from the first experiment, they suggested that the DSNs could have had different effects depending on the level of environmental awareness of the sample: Differences between majority and minority DSNs may only have occurred among the less environmentally concerned business students, while in the more environmentally concerned group of all students the mere activation of social norms may have been sufficient (vs. the control group).

Richter et al. (2018) posted signs using seven DSNs, ranging from 4% to 91%, to promote sustainable seafood in a field experiment conducted in Norway and Germany. They did not find significant differences when all social norm appeals were compared, but they found intercountry differences with Norwegian supermarkets selling proportionately more sustainable seafood. When they divided the DSNs by minority (<50%) and majority (>50%), only a sign reminding consumers of the possibility of buying sustainable seafood (control group) in Norway showed an effect. In Germany, however, they found a significant decrease in sustainable seafood sales for minority DSNs. Moreover, they showed that the total amount of seafood sold increased significantly during the experiment, which confirmed that the intervention had an effect but not the intended one. In accordance with Demarque et al. (2015), they concluded that in the case of minority behavior, it was risky to emphasize this fact through a DSN and that there might be differences depending on the population.

Aruta (2022) investigated gender differences between a majority (80%) and a minority DSN (20%), as women seemed to have stronger pro-environmental attitudes than men. Men in the majority DSN condition reported a higher intention to reduce their plastic use than men in the minority condition. In the minority condition, women reported higher levels of plastic reduction intention than men did. There was no difference between women in the minority condition and women in the majority condition, indicating that there were fewer differences between minority and majority DSNs for people with higher pro-environmental attitudes. However, Aruta did not control for environmental awareness. Nevertheless, a recent study by Schorn and Wirth (2024) investigated DSNs and ISNs and

environmental dispositions in two-wave studies. In two studies, they found no interaction between environmental awareness or personal norms and the social norm appeals.

de Groot et al. (2021) investigated DSNs (20% vs. 80%) with personal norms as a moderator. Personal norms reflect feelings of moral obligation to do “the right thing” and are self-based expectations for behavior that result from an individuals’ internalized values (Cialdini et al., 1991). For participants with weak personal norms, a majority DSN resulted in stronger behavioral intentions than a minority DSN. For medium and strong personal norms, no differences were found depending on the DSN. Correspondingly, Carfora et al. (2022) investigated the moderating role of intrinsic motivation, which they operationalized as similar to personal norms. They concluded that a (dynamic) DSN seemed to be particularly effective among people with relatively weak intrinsic motivation. By contrast, Kácha and van der Linden (2021) found no significant interactions between moral norms and minority vs. majority DSNs. Nevertheless, they suggested that this could be due to the moral norms being measured prior to the stimulus, and that this activation of moral norms could have overridden the effects of the different DSNs.

Taken together, Aruta (2022), Carfora et al. (2022), de Groot et al. (2021), Demarque et al. (2015), and Richter et al. (2018) showed that sample characteristics could influence the effects of social norm appeals. Generally, DSNs appear to have greater effects on individuals with weaker pro-environmental attitudes or on populations that have been less likely to engage in sustainable behaviors. For individuals with strong pro-environmental attitudes, an appeal emphasizing sustainable behavior in general seems sufficient to evoke conformity. Moreover, Richter et al. (2018) concluded that minority DSNs could even lead to backfire effects when pro-environmental attitudes were already low. Nevertheless, Schorn and Wirth (2024) did not find positive or negative effects of social norm appeals depending on their participant’s environmental dispositions.

Q3: Under which conditions do static descriptive minority social norm appeals backfire?

Several studies have investigated minority behavior and provided inconclusive results regarding backfire effects. Player et al. (2018) used a minority DSN (25%) and asked people to turn off their engines when the barriers were down. However, they did not find significant differences compared with the control group, and descriptively, this led to a positive effect rather than a backfire effect. Kácha and van der Linden (2021) compared majority (83%) and minority (17%) DSNs and found no differences when feelings of obligation to do the right thing (moral norms) were measured before the stimulus. However, when moral norms were not activated by a pre-stimulus measurement, the minority appeal was less effective. Conversely, this means that static minority DSNs may not lead to backfire effects when moral norms are simultaneously activated.

Lee and Liu (2023) found no difference in the intention to get a flu shot between a minority DSN (35%) and a control group without social norm appeal. However, when considering meat consumption, the participants who viewed a minority DSN (35%)

had a significantly lower intention to reduce red meat consumption than those who were not exposed to any messages. Therefore, backfire effects occurred only for environmental behavior but not for health behavior, which could be due to getting a flu shot being a private and unseen behavior and meat consumption being a social behavior. When considering public contexts, the sensitivity to social proof and social pressure may be increased as compared to private behaviors which can enhance the susceptibility to social norm appeals (cf. Habib et al., 2021). At the same time, this would also lead to an increased susceptibility for backfire effects of minority DSNAs.

In a field experiment, Berger (2021) investigated how minority DSNAs could be used to promote reusable mugs instead of disposable paper cups. A constant appeal (“use mugs instead of paper cups”) was supplemented with descriptive numbers: Individuals were informed that either 22% (weak minority DSNA) or 41% of customers used reusable cups (strong minority DSNA). These numbers were updated weekly using real-world data. In the strong condition, the share of reusable cups increased from 40.9% to 71.1% during the intervention and remained at 63.8% 3 weeks later. However, in the weak condition, there was a backfire effect: The use of reusable cups decreased from 21.3% to 5.5% and was only 1.9% after the intervention. Therefore, the backfire effects were evident but only in the case of a weak descriptive minority norm. It may be possible that a negative spiral occurred when individuals recognized a negative trend after the first week. However, if a positive trend occurred, it was further reinforced until the desired behavior exceeded the threshold for the majority behavior (>50%).

Kormos et al. (2015) arrived at a similar conclusion a few years earlier. In their field experiment, the participants were randomly assigned to a strong (26% changed their behavior) minority DSNA condition, a weak (4% changed their behavior) minority DSNA condition, or a control group. No differences were found among the conditions at the end of the intervention. However, they found a linear trend within the intervention weeks: The amount of sustainable transportation increased from the control group to the weak minority DSNA and then to the stronger minority DSNA. Kormos et al. (2015) discussed these results as partly surprising and in contrast with those observing backfire effects for minority behavior. Nevertheless, their study differed from previous ones in that it not only reported the proportion of individuals who engaged in the desired behavior at the time but also indicated a change (“Since 1993, 26% of commuters at [our university] have switched to more sustainable modes of transport to campus”). Thus, they came to a conclusion similar to that of Berger (2021), suggesting that the perception of change could lead to an adjustment of behavior. This idea about pre conformity is the basis of studies that used dynamic DSNA to prevent the backfire effects of static DSNA.

Q4: How can dynamic descriptive social norm appeals prevent negative backfire effects by highlighting a trend in the behavior?

Sparkman et al. studied perceived social change and dynamic DSNAs extensively. Sparkman and Walton (2017) found a higher interest in reducing meat consumption using a dynamic minority DSNA (“in the last 5 years, 30% have started to change their

behavior”) than a static DSNA (“30% make an effort”). When they added a control condition without social norm appeal, they did not find differences between the social norm appeal conditions and the control group. However, descriptively, the control group fell between the social norm appeal conditions, indicating a backfire effect of static minority DSNAs. When they added another dynamic condition and the trend was expected to either continue in the near future or not, the interest was higher in the condition suggesting future growth than in the condition without future growth.

In subsequent years, Sparkman et al. (2020b) conducted additional field experiments using dynamic DSNAs without specifying a baseline frequency (e.g., “customers are starting to eat less meat”) and found modest positive effects of the dynamic DSNAs. Moreover, Sparkman et al. (2021) found that a dynamic DSNA was able to shift the intention to reduce meat consumption for 5 months (Sparkman et al., 2021).

Using a similar approach, Mortensen et al. (2019) examined trending norms. They investigated whether the undesirable backfire effects of static minority DSNAs could be counteracted by highlighting a trend (48%; “this has increased from 37%”). A dynamic minority DSNA (48%; “this has increased from 37%”) caused significantly less water use than a static minority DSNA. Moreover, a marginal backfire effect of static minority DSNA was found and the water use was lower in the control condition than in the static condition. Furthermore, Loschelder et al. (2019) studied whether dynamic minority DSNAs could prevent the backfire effects of static minority DSNAs (25%). They described the trend without numbers and only stated that “more and more” people were changing their behavior. This dynamic DSNA had the strongest effect and performed significantly better than the static DSNA or control condition.

However, there are other studies that did not find positive effects of dynamic DSNAs. For example, Aldoh et al. (2021) replicated the study by Sparkman and Walton (2017) conceptually and compared static vs. dynamic DSNA (without future growth) with a control condition. However, they did not find any significant effects on the dependent variables. Descriptively, the interest in reducing meat consumption was lowest in the control group; thus, no backfire effects were found. Moreover, Schorn and Wirth (2023, 2024) and Chung and Lapinski (2023) did only find an indirect effect of the dynamic vs. static DSNA on behavioral intention when using perceived future descriptive norms as a mediator. Boenke et al. (2022) showed that a dynamic vs. static DSNA only led to higher intentions to reduce meat consumption when communicated by a researcher but not by a company representative or a vegan activist. They concluded that dynamic DSNA could backfire. However, since they did not include a control group in their (non-factorial) design, it was difficult to determine whether the dynamic DSNAs backfired or were just less effective when communicated by partisan people, because both static and dynamic DSNAs led to higher intentions when communicated by a researcher. In terms of red meat consumption and flu vaccinations, Lee and Liu (2023) did not find differences between static (30%/35%) and dynamic DSNAs without indicating future growth (cf. Sparkman and Walton, 2017). Nevertheless, they complemented their DSNA with a direct appeal (e.g., “get your flu shot”), which had already led to considerably smaller differences

between dynamic and static DSNAs in Loschelder et al.'s (2019) study. However, Buvár et al. (2023), Carfora et al. (2022), Gossen et al. (2023), and Sparkman et al. (2020a,b) did also not find a positive effect of a dynamic DSNA. In particular, when comparing dynamic DSNAs against control groups other than static minority DSNAs, dynamic DSNAs may be less effective (e.g., DellaValle and Zubaryeva, 2019; He et al., 2019).

Taken together, dynamic DSNAs seem to be a promising approach to promote minority behavior, especially when indicating ongoing future growth. However, the positive effects could have been overestimated, especially at the beginning, and the effects are now being modified with additional research. Specifically, when comparing dynamic DSNAs with a control group without social norm appeals (compared with static minority DSNAs), dynamic DSNAs seem to be less effective (Buvár et al., 2023; DellaValle and Zubaryeva, 2019; He et al., 2019; Carfora et al., 2022). Nevertheless, field experiments (Kormos et al., 2015; Loschelder et al., 2019) have suggested that dynamic DSNAs could be particularly effective over a longer period because they could then develop their full effect. Nevertheless, dynamic DSNAs appear to be preferable to static minority DSNAs, as backfire effects are unlikely, even if they may not effectively promote sustainable minority behavior.

Effects of injunctive social norm appeals

Aside from using dynamic DSNAs, another strategy to prevent backfire effects is to highlight and activate injunctive norms (Schultz et al., 2007). The first finding was that all studies on minority behavior applied ISNAs that described the approval within a reference group (approving ISNAs) and not ISNAs that described that the behavior should be performed or that a reference group expects the behavior (prescriptive ISNAs; Schorn et al., 2023). Nevertheless, some studies on minority behavior were excluded from the process because they used direct behavioral appeals without stating an injunctive norm (e.g., Loschelder et al., 2019).

Q5: How do the effects of injunctive social norm appeals depend on the strength of the social norm appeal?

In an early study on the topic, Schultz et al. (2008) described that “some” vs. “many” people supported sustainable behavior. However, they did not find significant differences between the two groups. Similarly, Smith et al. (2012) did not find a main effect on behavioral intention based on their manipulation of approval regarding energy conservation measures in two studies (23% vs. 85%). de Groot and Schuitema (2012) found that the acceptability of a measure was higher when the behavior had been approved by a majority (80%–89%) than by a minority (10%–20%), but they did not measure persuasive outcomes. Moreover, there is a very recent study by Liu and Lapinski (2024) that compared minority (“only a few”) and majority ISNA (“the majority”). They did not find direct effects of ISNA on the behavioral intention, but an indirect effect mediated by perceived injunctive norms. However,

they not only manipulated ISNAs, but also DSNAs (although the interaction was not taken into account in the analyses) and the effects of ISNAs can therefore not be assessed independently of the effects of DSNAs.

Lalot et al. (2019) conducted studies in the context of conversion theory (Moscovici, 1980). They described that a numerical minority (4%–18%) or majority (61%–82%) declare support and intent to make individual efforts, which is why they appeared to use a mix between ISNAs and DSNAs. Such a majority social norm appeal increased behavioral intentions. However, a minority social norm appeal and the control condition (no social norm appeal) only had a positive effect on people who engaged in green behavior in the past but not on those who reported less green behavior in the past. In another study, Lalot et al. (2018) found that a minority social norm appeal could be even more effective than a majority appeal when making participants feel good about their own environmental behavior. When making participants feel less good about their own environmental behavior, the majority social norm appeal increased willingness to participate in a pro-environmental event. Therefore, the participants who were led to believe that their behavior was insufficient were more willing to compensate for that when they believed that a majority (vs. minority) supported environmental values. Conversely, the participants who were led to believe that their behavior was sufficient maintained their efforts only when they believed that a minority supported those values, while self-licensing occurred when the majority supported those values. Therefore, Lalot et al. concluded that (injunctive) social norm appeals had different effects depending on individuals' environmental dispositions. One explanation for the opposing results to those of research on DSNAs, could be that their appeals may rather constitute ISNAs than DSNAs (because support and intentions were described): Different DSNAs could have stronger effects on individuals with weak environmental dispositions, while different ISNAs could have stronger effects on individuals with strong environmental dispositions (cf. Lalot et al., 2018).

Taken together, research suggests that ISNAs are less prone to backfire effects than DSNAs when promoting sustainable behavior and there were little differences between majority and minority ISNAs. Nevertheless, the studies comparing minority and majority ISNAs did typically not include control groups without an ISNAs which means that it is hard to tell if the minority and majority ISNAs may be equally effective or ineffective. Moreover, in most studies in which ISNAs were manipulated, DSNAs were manipulated as well. For example, Schultz et al. (2008) and Smith et al. (2012) who did not find main effects of ISNAs, found interaction effects between injunctive and DSNAs.

Effects of the alignment of social norm appeals

Only a few studies have been conducted on the alignment of social norm appeals (see Table A1). The studies differ in that in some cases no full design was used (e.g., no minority ISNA in Schorn and Wirth, 2023, 2024) or not all combinations were statistically analyzed (e.g., Schultz et al., 2008; Liu and Lapinski,

2024). In addition, numbers were used for DSNAs in some studies, while the proportion in ISNA was vaguely described (e.g., [Schultz et al., 2008](#); [Liu and Lapinski, 2024](#)). Other studies used numbers for ISNAs and DSNAs (e.g., [Smith et al., 2012](#)).

Q6: How does the alignment of descriptive and injunctive social norm appeals affect their impact?

[Schultz et al. \(2008\)](#) combined a majority (“many”) vs. a minority (“some”) ISNA with a DSN and determined whether a majority (75%) vs. a minority (25%) reused their towels. They showed a significant difference between the aligned majority social norm appeals and all other conditions, with the aligned majority social norm appeals being the most effective. Unfortunately, they reported only the results for this contrast. Similarly, [Liu and Lapinski \(2024\)](#) combined minority (“a few”) and majority (“the majority”) ISNAs with minority (20%) and majority (80%) DSNAs. Although the effects of ISNAs and DSNAs can therefore not be considered independently, no interaction effects on persuasive outcomes were reported. The results of the manipulation checks showed no interaction effects, but weak spillover effects between the social norms in addition to the expected effects: ISNAs had a weak effect on perceived descriptive norms and DSNAs had a weak effect on perceived injunctive norms.

Moreover, as previously mentioned, [Smith et al. \(2012\)](#) did not find main effects for majority vs. minority descriptive and ISNAs, but they found an interaction: When a majority DSN (82%) was combined with a majority ISNA (85%), the intentions to conserve energy were higher than when a majority DSN was complemented with a minority ISNA (23%) or when a majority ISNA was paired with a minority DSN. However, when using a minority ISNA, no significant differences were found between the descriptive majority and minority social norm appeals. In sum, the participants in the aligned majority social norm condition reported stronger intentions to engage in energy conservation than did the participants in either the unaligned conditions or the aligned minority social norm appeal condition.

Nevertheless, recent studies by [Schorn and Wirth \(2023, 2024\)](#) did not find indications of social norm conflict when combining a majority ISNA (80%) with a minority DSN (10%). However, unlike the other studies, they did not vary the strength of the ISNA but only compared the presence or absence of a majority ISNA in combination with a static, dynamic, or no DSN. However, similar to [Liu and Lapinski \(2024\)](#), they found effects on perceived social norms: There were not only the expected main effects of DSN and ISNA but also spillover effects and the majority ISNA proved to be particularly beneficial, as it had a desirable influence on both perceived injunctive and descriptive norms, as long as the prevalence of the behavior was not explicitly mentioned (no minority DSN including a baseline). Minority DSNs were also able to influence perceived injunctive norms, but this was a disadvantage in the case of minority behavior. Even though no direct effects on behavioral intention were found, the results of a mediation analysis suggest that DSNs and ISNAs can indirectly influence behavioral intention via perceived social norms ([Schorn and Wirth, 2024](#)). Moreover, there were interaction effects between DSN and ISNA that suggest that majority ISNAs can prevent the negative effects of minority DSNs on perceived norms, but

their positive effect on perceived injunctive norms and persuasive outcomes is not diminished by minority DSNs. [Schorn and Wirth \(2024\)](#) conclude that possible negative effects of conflicting social norm appeals cannot be explained by the effects of DSN and ISNA on perceived social norms but must have other origins. Nevertheless, they did not include minority ISNAs in their study, and due to incomplete research design, only limited statements can be made on how these effects on perceived social norms explain (absent) effects on behavioral intentions. [Smith et al. \(2012\)](#) demonstrated that the combination of majority DSN and majority ISNA was the most effective and derive the negative effects of conflicting norm appeals from the contrast to this condition—a combination that was not investigated by [Schorn and Wirth \(2023, 2024\)](#).

Taken together, it is still not clear if the combination of (majority) ISNAs and (minority) DSNs is problematic in the context of sustainable behavior. [Smith et al. \(2012\)](#) and [Schultz et al. \(2008\)](#) found interactions between DSNs and ISNAs when using students or hotel guests as rather narrow reference group. [Schorn and Wirth \(2023, 2024\)](#) did not find interaction effects but they used the German population as rather broad reference group and did not include minority ISNAs. When extending the view to areas other than sustainable behavior, there have been studies on organ donations that show even positive effects of conflicting social norm appeals ([Habib et al., 2021](#)). Therefore, more research on conflicting social norms is needed and researchers should also include perceived social norms to be able to provide insight into the mechanisms of operation of conflicting social norms and norm appeals, which may explain positive and negative effects.

Discussion

In this review, 36 articles, including 54 studies, applying social norm appeals to promote sustainable minority behavior were reviewed and discussed. Overall, there has been an increased number of studies on social norm appeals to promote sustainable behavior performed by a numerical minority of people. Most studies have indicated that minority DSNs are not effective in promoting sustainable behavior (e.g., [Richter et al., 2018](#); [Shealy et al., 2018](#); [Berger, 2021](#)). Moreover, some indicated that the use of static minority DSNs was unpredictable and could backfire ([Richter et al., 2018](#); [Mortensen et al., 2019](#); [Berger, 2021](#)). However, environmental dispositions of the population could play a significant role in the outcome ([Demarque et al., 2015](#); [Richter et al., 2018](#); [de Groot et al., 2021](#); [Aruta, 2022](#)). It appears that DSNs have a stronger effect on communities with lower pro-environmental attitudes or in populations with a lower baseline level of sustainable behaviors. People with higher pro-environmental attitudes seemed to be less affected. Results may be reversed for ISNA (cf. [Lalot et al., 2018](#)) but there is a need for further research because these results are partly implicit, explorative, or not robust which is why studies are necessary to clarify if cultural or environmental dispositions have a relevant effect on the impact of (minority) social norm appeals.

When a trend in the minority behavior was highlighted, most studies revealed positive effects (e.g., [Sparkman and Walton, 2017](#); [Loschelder et al., 2019](#); [Mortensen et al., 2019](#); [de Groot, 2022](#)). However, it appears that dynamic DSNs were more likely to catch

backfire effects from static minority DSNAs, as the overall results were weaker when dynamic DSNAs were compared against the control groups without social norm appeals (e.g., Buvár et al., 2023; DellaValle and Zubaryeva, 2019; Carfora et al., 2022; Gossen et al., 2023). Nevertheless, dynamic DSNAs may be particularly effective over a longer period because change can then be experienced, and they can develop their full effect (e.g., Kormos et al., 2015; Loschelder et al., 2019; Berger, 2021, study 1). In line with that, several studies have suggested that the effect of dynamic DSNAs is mediated by pre conformity or perceived future descriptive norms (e.g., Loschelder et al., 2019; Chung and Lapinski, 2023; Schorn and Wirth, 2023). Future studies should therefore look more closely at how dynamic DSNAs work over a longer period of time and what effect the adjustment of dynamic DSNAs has within this period. In this context, for example, effects in social media could also be considered and it could be examined whether algorithms affect social norms and reinforce the effects of and social norm appeals (Lutkenhaus et al., 2023; Schorn and Wirth, 2024).

In addition, there could be differences depending on the wording or presentation of the trend (cf. Sparkman and Walton, 2017; de Groot et al., 2021; de Groot, 2022). More research is necessary to determine if these differences are crucial for the persuasive effects and for example, it could be relevant if the trend is expected to continue in the future or not (cf. Sparkman and Walton, 2017). Additionally, dynamic DSNAs may be more effective if they include numbers, and the trend is not only described vaguely (“more and more”). Numeric DSNAs could be more credible than vague DSNAs although there may be no differences regarding persuasive effects (Schorn, 2023).

Furthermore, it has not yet been investigated in the context of sustainable behaviors whether dynamic DSNAs have a similar effect or may be even more effective than majority DSNAs. Chung and Lapinski (2023) included dynamic minority DSNAs and static majority DSNAs but only reported the effects mediated by perceived descriptive future norms. Nevertheless, a dynamic DSN (an increase from 9% to 30%) led to a higher perceived future descriptive norm than a static majority DSN (65%), which had a positive effect on behavioral intentions. However, they only found this effect for unplugging electronic devices but not for bringing one's own bags for grocery shopping to reduce plastic waste. Moreover, a very recent study by Zumthurm and Stämpfli (2024) used a dynamic DSN which described the shift from minority to majority behavior (“In Switzerland, more and more people are reducing their meat consumption. Whereas 10 years ago, it was 40 % of the population that occasionally refrained from meat, today it is 60 %, which have adjusted their eating habits and occasionally refrain from meat”). They did not find significant differences to the control group without an appeal—although 60% is even majority behavior.

In addition to dynamic DSNAs, (majority) ISNAs can be used to prevent the backfire effects of (static) minority DSNAs because they seem to be less prone to backfire effects (Schultz et al., 2008). There were little differences between majority and minority ISNAs, but the studies typically did not include control groups without an ISNAs which means that it is hard to tell if the minority and majority ISNAs are equally effective or ineffective (e.g., de Groot and Schuitema, 2012). However, Schorn and Wirth (2023, 2024) conclude that majority ISNAs can have a positive effect in the

context of minority behavior, but they only compared a majority ISNA to the control group. Nevertheless, minority ISNAs may be effective because individuals could spend more attention on measures supported by a few people, and this could lead to a stronger internalization of reasons for engaging in the behavior (Lalot et al., 2019). Unlike DSNAs that typically work heuristically through the peripheral route of information, ISNAs need more elaboration to make the “right” choice (Göckeritz et al., 2009; Melnyk et al., 2019). This conscious decision can be more stable and can have an impact on different future situations. Therefore, when individuals think about good motives to engage in behavior supported by a minority of people, a resulting agreement with the minority position could increase people's motivation to adopt the behavior (Lalot et al., 2019). Nevertheless, open questions remain specifically about the effectiveness of ISNAs stating majority approval in the context of minority behavior because most of the studies combined ISNAs with DSNAs.

When looking at studies on conflicting social norms, the results are ambiguous. In early studies, it was problematic when a majority ISNA did not align with a majority DSNAs (e.g., Smith et al., 2012). When looking at the greater picture, these results suggest that majority ISNAs may be fragile because even if the descriptive minority norm is not made salient in the appeal, people still have an idea about whether the behavior is performed in general, as they quite accurately infer social norms through their observation of others, personal and media communication, and self-knowledge (Cialdini et al., 1991; Miller and Prentice, 1996; Witzling et al., 2019; Griesoph et al., 2021). Survey studies have shown that such perceived norms strongly influence behavior (e.g., Borg et al., 2020; Jacobson et al., 2020). Even if the injunctive norm was perceived as strong, which could be reinforced through the majority ISNA, it was problematic when it did not align with the perceived descriptive norm because the effect of an ISNA could be moderated through perceived descriptive norms (Thøgersen, 2008; Witzling et al., 2019; Jacobson et al., 2020). In this case, people could experience an inner conflict or cognitive dissonance, which could suppress the desired behavior (cf. Thøgersen, 2008; Jacobson et al., 2020). Especially when a behavior involves effort, people may question why they should act when no one else does. As sustainable behavior often represents a social dilemma, individuals may have no direct benefit but have costs and effort instead (Thøgersen, 2008).

Conversely, Schorn and Wirth; Schorn and Wirth (2023; 2024, study 1) did not find undesirable effects caused by a social norm conflict or nullification of the main effects when combining a majority ISNA with a static or dynamic DSN. However, they discussed whether this could be caused by the online environment because a majority ISNA showed the participants the “right” thing to do, and as there was no cost to providing that answer, the participants might do so. On the one hand, it can be argued that social desirability is of minor importance in an online setting, because the behavior is anonymous and not publicly visible. On the other hand, the effect of social norm appeals may have been weakened precisely by the fact that the actions were not publicly visible, but the behavior was carried out in private. Social norm appeals may have stronger impacts in public contexts because such contexts may increase the influence of social proof and social pressure and therefore the sensitivity to norm manipulations (Habib et al., 2021).

Nevertheless, in health communication, [Habib et al. \(2021\)](#) even came to the conclusion that a minority DSN in combination with a majority ISNA could result in greater organ donor registrations than either of them separately. This could be due to the discrepancy between what people think they should do and what they actually do becoming the most salient. However, organ donation could have direct consequences for one individual, whereas sustainable behavior would only be effective if it was implemented by a sufficiently large number of people. At the same time, individuals could run along in this crowd without doing anything themselves when a sufficient majority engages in sustainable behavior ([Thøgersen, 2008](#); [Lalot et al., 2019](#)). Moreover, there may have been a shift in times with regard to sustainable behavior because media reporting on the climate crisis has significantly changed since the early studies on social norm conflict and the topic is now more relevant (cf. [Smith and Louis, 2008](#); [McDonald et al., 2014](#)). Following this line of argumentation, the injunctive majority approving the behavior may now be stronger manifested in society and an attitude–behavior gap appear more legitimate because structural measures are often demanded instead of changing one's own behavior. When reminding individuals that a behavior is approved by a majority but yet only performed by a minority of people, this could be a strong motivator because social rewards may be particularly attractive. In this case, the adoption of the behavior would be rather driven by social rewards than by the fear of social sanctions. Furthermore, studies addressing sustainable behavior often used topics that are not relevant to the single individual, and in this case, social norm appeals could operate heuristically and without deep elaboration ([Smith and Louis, 2008](#)). If the topic was personally relevant (cf. [Habib et al., 2021](#)) or explained in detail ([Schorn and Wirth, 2023](#)), individual group members might feel an obligation or a stronger motivation to engage in the course of action when no one else does.

To provide further insight into the effect of conflicting social norm appeals, future research could examine if there are differences depending on the formulation of conflicting social norm appeals. Most studies using DSNs have focused on statistics or numeric information, while some of the studies used vague wording for ISNAs. Nevertheless, there is an increasing number of studies that use vague formulations of a trend as dynamic DSN ([Bergquist and Nilsson, 2019](#); [Bergquist et al., 2020](#); [Loschelder et al., 2019](#), study 1; [Schultz et al., 2008](#)). Within social norm conflicts, the injunctive majority could be emphasized in a numeric ISNA combined with vague wording for the minority DSN to mitigate the perception of incongruent injunctive and descriptive norms. Moreover, majority ISNAs could be combined with dynamic DSNs. [Schorn and Wirth \(2023, 2024\)](#) did not find positive effects of combining majority ISNAs with dynamic DSNs, but studies on this combination are limited to date. Furthermore, instead of highlighting the increasing minority performing the behavior (e.g., increase to 30%), social norm appeals could highlight the decreasing majority (e.g., decrease to 70%) not engaging in the target behavior ([de Groot, 2022](#)). Finally, the combination of dynamic majority ISNAs and static minority DSNs could be investigated (e.g., “an increasing majority supports the behavior, although only a few perform the behavior yet”).

Overall, there is still a need for further research investigating social norm appeals to promote sustainable minority behavior

approved by most people. This research should particularly focus on interventions in real-world settings and investigate how they can influence perceived social norms over extended periods and, consequently, effectuate lasting behavioral changes. Such studies may consider the combination of majority ISNAs with dynamic DSNs or vaguely formulated social norm appeals, as these approaches appear to have potential. In addition, it should be further investigated under which conditions social norm appeals are effective in the long term and what role individual characteristics, such as environmental concerns or personal norms, play in this.

Conclusion

This literature review discussed studies that use social norm appeals in the context of sustainable minority behavior. It is striking that most studies refer to descriptive norms and only a few considered injunctive norms, although the combination is very relevant, especially in the area of sustainable behavior. Overall, it is not yet clear how effective social norm appeals are in promoting minority behavior but it is worthwhile to investigate social norm appeals in this context: They are typically easy to implement without incurring high costs and according to conversion theory, minority influence is the “true” influence, while majority influence is superficial ([Moscovici, 1980](#)). Therefore, social norm appeals could result in stronger and more stable changes in attitudes and behavior if they do not backfire ([Lalot et al., 2019](#)). Under specific circumstances, minority social norm appeals may even increase the urgency to act when individuals realize how critical the issue is ([Habib et al., 2021](#)). Nevertheless, the activation and adjustment of (perceived) injunctive majority norms appears to be especially effective because they are often underestimated and majority ISNAs can not only adjust such misperceptions but also have positive spillover effects on perceived descriptive norms ([Schorn and Wirth, 2024](#)). Therefore, for practitioners, emphasizing ongoing social change toward the desired behavior and highlighting majority approval seem to be simple strategies with great potential to induce compliance and encourage sustainable minority behavior without running the risk of undesirable backfire effects.

Author contributions

AS: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated

References

- Abrahamse, W., and Steg, L. (2013). Social influence approaches to encourage resource conservation: A meta-analysis. *Global Environm. Change* 23, 1773–1785. doi: 10.1016/j.gloenvcha.2013.07.029
- Aldoh, A., Sparks, P., and Harris, P. R. (2021). Dynamic norms and food choice: Reflections on a failure of minority norm information to influence motivation to reduce meat consumption. *Sustainability* 13:8315. doi: 10.3390/su13158315
- Andre, P., Boneva, T., Chopra, F., and Falk, A. (2024). Globally representative evidence on the actual and perceived support for climate action. *Nat. Climate Change* 14, 253–259. doi: 10.1038/s41558-024-01925-3
- Aruta, J. J. B. R. (2022). An extension of the theory of planned behavior in predicting intention to reduce plastic use in the Philippines: Cross-sectional and experimental evidence. *Asian J. Social Psychol.* 25, 406–420. doi: 10.1111/ajsp.12504
- Baiardi, D., and Morana, C. (2021). Climate change awareness: empirical evidence for the European Union. *Energy Econ.* 96:105163. doi: 10.1016/j.eneco.2021.105163
- Berger, J. (2021). Social tipping interventions can promote the diffusion or decay of sustainable consumption norms in the field: evidence from a quasi-experimental intervention study. *Sustainability* 13:3529. doi: 10.3390/su13063529
- Bergquist, M., and Nilsson, A. (2019). The DOs and DON'Ts in social norms: a descriptive don't-norm increases conformity. *J. Theoret. Soc. Psychol.* 3, 158–166. doi: 10.1002/jts5.43
- Bergquist, M., Nyström, L., and Nilsson, A. (2020). Feeling or following? A field-experiment comparing social norms-based and emotions-based motives encouraging pro-environmental donations. *J. Consum. Behav.* 19, 351–358. doi: 10.1002/cb.1813
- Boenke, L., Panning, M., Thurow, A., Hörisch, J., and Loschelder, D. D. (2022). Who can nudge for sustainable development? How nudge source renders dynamic norms (in-)effective in eliciting sustainable behavior. *J. Clean. Prod.* 368:133246. doi: 10.1016/j.jclepro.2022.133246
- Bonan, J., Cattaneo, C., d'Adda, G., and Tavoni, M. (2020). The interaction of descriptive and injunctive social norms in promoting energy conservation. *Nature Energy* 5, 900–909. doi: 10.1038/s41560-020-00719-z
- Borg, K., Curtis, J., and Lindsay, J. (2020). Social norms and plastic avoidance: testing the theory of normative social behavior on an environmental behavior. *J. Consumer Behav.* 19, 594–607. doi: 10.1002/cb.1842
- Brechin, S. R., and Bhandari, M. (2011). Perceptions of climate change worldwide. *WIREs Climate Change* 2, 871–885. doi: 10.1002/wcc.146
- Buvár, Á., Zsila, Á., and Orosz, G. (2023). Non-green influencers promoting sustainable consumption: dynamic norms enhance the credibility of authentic pro-environmental posts. *Front. Psychol.* 14:112762. doi: 10.3389/fpsyg.2023.1112762
- Carfora, V., Zeiske, N., van der Werff, E., Steg, L., and Catellani, P. (2022). Adding dynamic norm to environmental information in messages promoting the reduction of meat consumption. *Environm. Commun.* 2022, 1–20. doi: 10.1080/17524032.2022.2062019
- Chung, A., and Rimal, R. N. (2016). Social norms: a review. *Rev. Commun. Res.* 4, 1–28. doi: 10.12840/issn.2255-4165.2016.04.01.008
- Chung, M., and Lapinski, M. K. (2023). The effect of dynamic norms messages and group identity on pro-environmental behaviors. *Communic. Res.* 51:009365022311766. doi: 10.1177/00936502231176670
- Cialdini, R. B. (2003). Crafting normative messages to protect the environment. *Curr. Dir. Psychol. Sci.* 12, 105–109. doi: 10.1111/1467-8721.01242
- Cialdini, R. B., and Jacobson, R. P. (2021). Influences of social norms on climate change-related behaviors. *Curr. Opin. Behav. Sci.* 42, 1–8. doi: 10.1016/j.cobeha.2021.01.005
- Cialdini, R. B., Kallgren, C. A., and Reno, R. R. (1991). A focus theory of normative conduct: a theoretical refinement and reevaluation of the role of norms in human behavior. *Adv. Experim. Soc. Psychol.* 24, 201–234. doi: 10.1016/S0065-2601(08)60330-5
- Cialdini, R. B., Reno, R. R., and Kallgren, C. A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *J. Pers. Soc. Psychol.* 58, 1015–1026. doi: 10.1037/0022-3514.58.6.1015
- de Groot, J. I. M. (2022). The effectiveness of normative messages to decrease meat consumption: The superiority of dynamic normative messages framed as a loss. *Front. Sustain.* 3:968201. doi: 10.3389/frsus.2022.968201
- de Groot, J. I. M., Bondy, K., and Schuitema, G. (2021). Listen to others or yourself? The role of personal norms on the effectiveness of social norm interventions to change pro-environmental behavior. *J. Environm. Psychol.* 78:101688. doi: 10.1016/j.jenvp.2021.101688
- de Groot, J. I. M., and Schuitema, G. (2012). How to make tJ. Environ. Psychol. he unpopular popular? Policy characteristics, social norms and the acceptability of environmental policies. *Environm. Sci. Policy.* 19–20, 100–107. doi: 10.1016/j.envsci.2012.03.004
- DellaValle, N., and Zubaryeva, A. (2019). Can we hope for a collective shift in electric vehicle adoption? Testing salience and norm-based interventions in South Tyrol, Italy. *Energy Res. Soc. Sci.* 55, 46–61. doi: 10.1016/j.erss.2019.05.005
- Demarque, C., Charalambides, L., Hilton, D. J., and Waroquier, L. (2015). Nudging sustainable consumption: the use of descriptive norms to promote a minority behavior in a realistic online shopping environment. *J. Environ. Psychol.* 43, 166–174. doi: 10.1016/j.jenvp.2015.06.008
- Economist Intelligence Unit (2021). *An Eco-Wakening: Measuring Awareness, Engagement, and Action for Nature*. Gland: WWF. Available at: https://files.worldwildlife.org/wwfcmprod/files/Publication/file/93ts5bhvyq_An_EcoWakening_Measuring_awareness_engagement_and_action_for_nature_FINAL_MAY_2021.pdf
- European Commission (2020). *Special Eurobarometer 501: Attitudes of Europeans Towards the Environment*. Brussels: European Commission. Available at: <https://europa.eu/eurobarometer/surveys/detail/2257> (accessed September 4, 2023).
- European Commission (2021). *Special Eurobarometer 513: Climate Change [Dataset]*. Brussels: European Commission. Available at: http://data.europa.eu/88u/dataset/s2273_95_1_513_eng (accessed September 4, 2023).
- Farrow, K., Grolleau, G., and Ibanez, L. (2017). Social norms and pro-environmental behavior: A review of the evidence. *Ecol. Econ.* 140, 1–13. doi: 10.1016/j.ecolecon.2017.04.017
- Fell, H.-J., and Traber, T. (2020). *The Path to Climate Neutrality by 2050 Misses the Paris Climate Targets: The Rocky Road to Truthfulness in Climate Politics (EWG Policy Paper)*. Berlin: Energy Watch Group. Available at: https://www.energywatchgroup.org/wp-content/uploads/EWG_Policy-Paper_2021_Climate-Neutrality-2050.pdf
- Fishbein, M., and Ajzen, I. (1975). *Belief, Attitude, Intention and Behaviour: An Introduction to Theory and Research*, Vol. 27. Addison-Wesley.
- Ge, W., Sheng, G., and Zhang, H. (2020). How to solve the social norm conflict dilemma of green consumption: The moderating effect of self-affirmation. *Front. Psychol.* 11:566571. doi: 10.3389/fpsyg.2020.566571
- Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *Am. Psychol.* 66, 290–302. doi: 10.1037/a0023566
- Göckeritz, S., Schultz, P. W., Rendón, T., Cialdini, R. B., Goldstein, N. J., and Griskevicius, V. (2009). Descriptive normative beliefs and conservation behavior: the moderating roles of personal involvement and injunctive normative beliefs. *Eur. J. Soc. Psychol.* 40, 514–523. doi: 10.1002/ejsp.643
- Goldstein, N. J., Cialdini, R. B., and Griskevicius, V. (2008). A room with a viewpoint: Using social norms to motivate environmental conservation in hotels. *J. Consum. Res.* 35, 472–482. doi: 10.1086/586910
- Gossen, M., Tröger, J., Veneny, M., Eichhorn, H., and Bergener, J. (2023). Do people make sufficiency-oriented mobile phone choices based on dynamic norms? The perception and effectiveness of sufficiency-promoting messages in online media. *Front. Sustain.* 4:1145243. doi: 10.3389/frsus.2023.1145243
- Griesoph, A., Hoffmann, S., Merk, C., Rehdanz, K., and Schmidt, U. (2021). Guess what...? How guessed norms nudge climate-friendly food choices in real-life settings. *Sustainability* 13:8669. doi: 10.3390/su13158669
- Habib, R., White, K., and Hoegg, J. (2021). Everybody thinks we should but nobody does: how combined injunctive and descriptive norms motivate organ donor registration. *J. Consumer Psychol.* 31, 621–630. doi: 10.1002/jcpsy.1220
- He, H., Fu, J., Li, X., and Guo, R. (2019). The interplay between endorser social status and normative appeals on the endorsement effectiveness of pro-environmental behaviors. *PLoS ONE* 14:e0210699. doi: 10.1371/journal.pone.0210699
- Helferich, M., Thøgersen, J., and Bergquist, M. (2023). Direct and mediated impacts of social norms on pro-environmental behavior. *Global Environm. Change* 80:102680. doi: 10.1016/j.gloenvcha.2023.102680

- Hertwich, E. G., and Peters, G. P. (2009). Carbon footprint of nations: a global, trade-linked analysis. *Environ. Sci. Technol.* 43, 6414–6420. doi: 10.1021/es803496a
- IPCC (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg1/#SPM>
- Jacobson, R. P., Marchiondo, L. A., Jacobson, K. J. L., and Hood, J. N. (2020). The synergistic effect of descriptive and injunctive norm perceptions on counterproductive work behaviors. *J. Busin. Ethics* 162, 191–209. doi: 10.1007/s10551-018-3968-1
- Kácha, O., and van der Linden, S. (2021). The moderating role of moral norms and personal cost in compliance with pro-environmental social norms. *Curr. Res. Ecol. Soc. Psychol.* 2:100020. doi: 10.1016/j.cresp.2021.100020
- Kormos, C., Gifford, R., and Brown, E. (2015). The influence of descriptive social norm information on sustainable transportation behavior: a field experiment. *Environ. Behav.* 47, 479–501. doi: 10.1177/0013916513520416
- Lacroix, K., Gifford, R., and Chen, A. (2019). Developing and validating the Dragons of Inaction Psychological Barriers (DIPB) scale. *J. Environ. Psychol.* 63, 9–18. doi: 10.1016/j.jenvp.2019.03.001
- Lalot, F., Falomir-Pichastor, J. M., and Quiamzade, A. (2018). Compensation and consistency effects in proenvironmental behavior: the moderating role of majority and minority support for proenvironmental values. *Group Proc. Intergroup Relat.* 21, 403–421. doi: 10.1177/1368430217733117
- Lalot, F., Quiamzade, A., Falomir-Pichastor, J. M., and Gollwitzer, P. M. (2019). When does self-identity predict intention to act green? A self-completion account relying on past behavior and majority-minority support for pro-environmental values. *J. Environ. Psychol.* 61, 79–92. doi: 10.1016/j.jenvp.2019.01.002
- Lapinski, M. K., Zhuang, J., Koh, H., and Shi, J. (2017). Descriptive norms and involvement in health and environmental behaviors. *Commun. Res.* 44, 367–387. doi: 10.1177/0093650215605153
- Lee, S. J., and Liu, J. (2023). Leveraging dynamic norm messages to promote counter-normative health behaviors: The moderating role of current and future injunctive norms, attitude and self-efficacy. *Health Commun.* 38, 1071–1079. doi: 10.1080/10410236.2021.1991638
- Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C.-Y., and Leiserowitz, A. A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nat. Clim. Chang.* 5, 1014–1020. doi: 10.1038/nclimate2728
- Legros, S., and Cislighi, B. (2020). Mapping the social-norms literature: an overview of reviews. *Perspectives on Psychological Science* 15, 62–80. doi: 10.1177/1745691619866455
- Liu, R. W., and Lapinski, M. K. (2024). Cultural influences on the effects of social norm appeals. *Philos. Trans. R Soc. Lond. B. Biol. Sci.* 379:20230036. doi: 10.1098/rstb.2023.0036
- Loschelder, D. D., Siepelmeyer, H., Fischer, D., and Rubel, J. A. (2019). Dynamic norms drive sustainable consumption: Norm-based nudging helps café customers to avoid disposable to-go-cups. *J. Econ. Psychol.* 75:102146. doi: 10.1016/j.joep.2019.02.002
- Lutkenhaus, R. O., McLarnon, C., and Walker, F. (2023). Norms-shifting on social media: A review of strategies to shift health-related norms among adolescents and young adults on social media. *Rev. Commun. Res.* 11, 127–149. doi: 10.5680/RCR.V11.5
- McDonald, R. I., Fielding, K. S., and Louis, W. R. (2014). Conflicting norms highlight the need for action. *Environ. Behav.* 46, 139–162. doi: 10.1177/0013916512453992
- Melnyk, V., van Herpen, E., Fischer, A. R. H., and van Trijp, H. C. M. (2013). Regulatory fit effects for injunctive vs. descriptive social norms: evidence from the promotion of sustainable products. *Mark. Lett.* 24, 191–203. doi: 10.1007/s11002-013-9234-5
- Melnyk, V., van Herpen, E., Jak, S., and van Trijp, H. C. M. (2019). The mechanisms of social norms' influence on consumer decision making: a meta-analysis. *Z. Psychol.* 227, 4–17. doi: 10.1027/2151-2604/a000352
- Miller, D. T., and Prentice, D. A. (1996). "The construction of social norms and standards," in *Social Psychology: Handbook of Basic Principles*. (New York: The Guilford Press), 799–829.
- Miller, D. T., and Prentice, D. A. (2016). Changing norms to change behavior. *Annu. Rev. Psychol.* 67, 339–361. doi: 10.1146/annurev-psych-010814-015013
- Mollen, S., Rimal, R. N., Ruiter, R. A. C., and Kok, G. (2013). Healthy and unhealthy social norms and food selection: findings from a field-experiment. *Appetite* 65, 83–89. doi: 10.1016/j.appet.2013.01.020
- Mortensen, C. R., Neel, R., Cialdini, R. B., Jaeger, C. M., Jacobson, R. P., and Ringel, M. M. (2019). Trending norms: a lever for encouraging behaviors performed by the minority. *Soc. Psychol. Personal. Sci.* 10, 201–210. doi: 10.1177/1948550617734615
- Moscovici, S. (1980). "Toward a theory of conversion behavior," in *Advances in Experimental Social Psychology*, ed. B. Leonard (San Diego, CA: Academic Press), 209–239.
- Nolan, J. M. (2021). Social norm interventions as a tool for pro-climate change. *Curr. Opin. Psychol.* 42, 120–125. doi: 10.1016/j.copsyc.2021.06.001
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 372:n71. doi: 10.1136/bmj.n71
- Passafaro, P. (2020). Attitudes and tourists' sustainable behavior: an overview of the literature and discussion of some theoretical and methodological issues. *J. Travel Res.* 59, 579–601. doi: 10.1177/0047287519851171
- Player, A., Abrams, D., Van de Vyver, J., Meleady, R., Leite, A. C., Randsley de Moura, G., et al. (2018). "We aren't idlers": using subjective group dynamics to promote prosocial driver behavior at long-wait stops. *J. Appl. Soc. Psychol.* 48, 643–648. doi: 10.1111/jasp.12554
- Poškus, M. S. (2016). Using social norms to encourage sustainable behavior: a meta-analysis. *Psichologija* 53, 44–58. doi: 10.15388/Psichol.2016.53.10031
- Poškus, M. S., Pilkauskaitė Valickienė, R., and Kuzinas, A. (2019). The effects of descriptive imagery and appeals on emotions and intentions related to pro-environmental behavior. *Sustainability* 11:5257. doi: 10.3390/su11195257
- Reno, R. R., Cialdini, R. B., and Kallgren, C. A. (1993). The transsituational influence of social norms. *J. Pers. Soc. Psychol.* 64, 104–112. doi: 10.1037/0022-3514.64.1.104
- Reynolds-Tylus, T., Martinez Gonzalez, A., and Quick, B. L. (2019). The role of choice clustering and descriptive norms in attenuating psychological reactance to water and energy conservation messages. *Environ. Commun.* 13, 847–863. doi: 10.1080/17524032.2018.1461672
- Rhodes, N., Shulman, H. C., and McClaran, N. (2020). Changing norms: a meta-analytic integration of research on social norms appeals. *Human Commun. Res.* 46, 161–191. doi: 10.1093/hcr/hqz023
- Richter, I., Thøgersen, J., and Klöckner, C. (2018). A social norms intervention going wrong: Boomerang effects from descriptive norms information. *Sustainability* 10:2848. doi: 10.3390/su10082848
- Rimal, R. N., and Lapinski, M. K. (2015). A re-explication of social norms, ten years later: Social norms. *Commun. Theory* 25, 393–409. doi: 10.1111/comt.12080
- Rinscheid, A., Pianta, S., and Weber, E. U. (2021). What shapes public support for climate change mitigation policies? The role of descriptive social norms and elite cues. *Behav. Public Policy* 5, 503–527. doi: 10.1017/bpp.2020.43
- Saracevic, S., and Schlegelmilch, B. B. (2021). The impact of social norms on pro-environmental behavior: A systematic literature review of the role of culture and self-construal. *Sustainability* 13:5156. doi: 10.3390/su13095156
- Schorn, A. (2023). "Promoting sustainable minority behaviour through social norm appeals: the impact of numeric versus vague formulations," in *Annual Conference of the Media Reception and Effects Division, German Communication Association, Augsburg, Germany*.
- Schorn, A., Schläpfer, S., and Wirth, W. (2023). "Promoting voluntary carbon offsetting through social norm appeals: some learnings from null results," in *Klima(wandel)kommunikation* (1st ed.), eds. J. Wolling, M. Becker, & C. Schumann. (Berlin: Universitätsverlag Ilmenau), 207–224.
- Schorn, A., and Wirth, W. (2023). Meet Bob and offset your flight: optimising explainer videos to promote voluntary carbon offsetting. *Media Commun.* 11:1. doi: 10.17645/mac.v11i1.6028
- Schorn, A., and Wirth, W. (2024). They approve but they don't act: promoting sustainable minority behavior with (conflicting) social norm appeals. *Front. Psychol.* 15, 1–18. doi: 10.3389/fpsyg.2024.1337585
- Schultz, P. W., Khazian, A. M., and Zaleski, A. C. (2008). Using normative social influence to promote conservation among hotel guests. *Soc. Influence* 3, 4–23. doi: 10.1080/15534510701755614
- Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., and Grisevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychol. Sci.* 18, 429–434. doi: 10.1111/j.1467-9280.2007.01917.x
- Schwartz, S. H. (1973). Normative explanations of helping behavior: a critique, proposal, and empirical test. *J. Exp. Soc. Psychol.* 9, 349–364. doi: 10.1016/0022-1031(73)90071-1
- Shealy, T., Johnson, E., Weber, E., Klotz, L., Applegate, S., Ismael, D., et al. (2018). Providing descriptive norms during engineering design can encourage more sustainable infrastructure. *Sustain. Cities Soc.* 40, 182–188. doi: 10.1016/j.scs.2018.04.017
- Sherif, M. (1936). *The Psychology of Social Norms*. Harper, xii, 210.
- Shulman, H., Rhodes, N., Davidson, E., Ralston, R., Borghetti, L., and Morr, L. (2017). The state of the field of social norms research. *Int. J. Commun.* 11:6055.
- Smith, J. R., and Louis, W. R. (2008). Do as we say and as we do: the interplay of descriptive and injunctive group norms in the attitude-behavior relationship. *Br. J. Soc. Psych.* 47, 647–666. doi: 10.1348/014466607X269748
- Smith, J. R., Louis, W. R., Terry, D. J., Greenaway, K. H., Clarke, M. R., and Cheng, X. (2012). Congruent or conflicted? The impact of injunctive and descriptive norms on environmental intentions. *J. Environm. Psychol.* 32, 353–361. doi: 10.1016/j.jenvp.2012.06.001

- Sparkman, G., Howe, L., and Walton, G. (2020a). How social norms are often a barrier to addressing climate change but can be part of the solution. *Behavioral Public Policy* 1–28. doi: 10.1017/bpp.2020.42
- Sparkman, G., Macdonald, B. N. J., Caldwell, K. D., Kateman, B., and Boese, G. D. (2021). Cut back or give it up? The effectiveness of reduce and eliminate appeals and dynamic norm messaging to curb meat consumption. *J. Environ. Psychol.* 75:101592. doi: 10.1016/j.jenvp.2021.101592
- Sparkman, G., and Walton, G. M. (2017). Dynamic norms promote sustainable behavior, even if it is counternormative. *Psychol. Sci.* 28, 1663–1674. doi: 10.1177/0956797617719950
- Sparkman, G., Weitz, E., Robinson, T. N., Malhotra, N., and Walton, G. M. (2020b). Developing a scalable dynamic norm menu-based intervention to reduce meat consumption. *Sustainability* 12:2453. doi: 10.3390/su12062453
- Thøgersen, J. (2008). Social norms and cooperation in real-life social dilemmas. *J. Econ. Psychol.* 29, 458–472. doi: 10.1016/j.joep.2007.12.004
- United Nations (2015). *The Sustainable Development Goals. 17 Goals to Transform Our World*. Available at: <https://www.un.org/sustainabledevelopment/>
- White, K., and Simpson, B. (2013). When do (and don't) normative appeals influence sustainable consumer behaviors? *J. Mark.* 77, 78–95. doi: 10.1509/jm.11.0278
- Witzling, L., Shaw, B., and Trechter, D. (2019). Which communication channels shape normative perceptions about buying local food? An application of social exposure. *Agricult. Human Values* 36, 443–454. doi: 10.1007/s10460-019-09926-1
- Wolf, I., Ebersbach, B., and Huttarsch, J.-H. (2023). Soziales Nachhaltigkeitsbarometer der Energie- und Verkehrswende 2023 (Soziales Nachhaltigkeitsbarometer). Potsdam: Potsdam-Institut für Klimafolgenforschung (PIK). Available at: <https://snb.ariadneprojekt.de/soziales-nachhaltigkeitsbarometer>
- Yamin, P., Fei, M., Lahlou, S., and Levy, S. (2019). Using social norms to change behavior and increase sustainability in the real world: a systematic review of the literature. *Sustainability* 11:5847. doi: 10.3390/su11205847
- Zumthurm, S., and Stämpfli, A. (2024). A diet-related health prompt with the Swiss Food Pyramid as a nudge to reduce meat consumption. *Food Qual. Prefer.* 115:105105. doi: 10.1016/j.foodqual.2024.105105

Appendix

Table A1 List of studies selected for the literature review.

References	Study	Method	Topic	Country	DSNA	ISNA	Control group	Exemplar minority appeal	Stimulus
Aldoh et al. (2021)	–	Experiment	Sustainable diet (meat consumption)	United Kingdom	30% vs. 30% (increasing) vs. control group	–	No stimulus	Recent research has shown that, in the last 5 years, 30% of people in the UK have now started to make an effort to limit their meat consumption.	Statement
Aruta (2022)	Study 2	Experiment	Waste prevention (plastic)	Philippines (students)	20% vs. 80%	–	–	Among these institutions, our university only has 20% of its students minimizing their daily plastic use.	Article
Berger (2021)	–	Field experiment	Waste prevention (reusable mugs)	Switzerland (students)	40.9% and 21.3%	–	Behavioral appeal No intervention	1st week of October. 22% are using mugs. Join them!	Sign
Boenke et al. (2022)	–	Experiment	Sustainable diet (meat consumption)	Germany, Switzerland, and Austria (convenience)	15% vs. more and more	–	–	15% of Germans try to reduce their meat consumption. This means that 15 out of 100 people eat less meat than they would normally do.	Statement
Buvár et al. (2023)	–	Experiment	Waste prevention (plastic)	Finland (convenience)	More and more vs. control group	–	Behavioral appeal	More and more people care about the PET pollution every day.	Instagram post
Carfora et al. (2022)	–	Experiment	Sustainable diet (meat consumption)	Italy (convenience)	More and more vs. control group	–	No social norm appeal	To avoid deforestation, more and more people are reducing their consumption of meat.	Chatbot
Chung and Lapinski (2023)	–	Experiment	Waste prevention Conservation (energy)	USA (students)	30% vs. 30% (increasing) vs. majority	–	–	More and more students (9% in 2017 → 17% in 2018 → 30% in 2019) are unplugging their electronics to save money, save energy, and to protect pure Michigan.	Poster
de Groot (2022)	–	Experiment	Sustainable diet (meat consumption)	Germany The Netherlands (students)	30% vs. 30% (increasing)	–	No stimulus	Recent research has shown that 30% of people living in the Netherlands make an effort to limit their meat consumption. This means that 3 out of 10 people living in the Netherlands eat less meat than they otherwise would. This has increased from 20% or 2 out of 10 people five years ago.	Statement

(Continued)

Table A1 (Continued)

References	Study	Method	Topic	Country	DSNA	ISNA	Control group	Exemplar minority appeal	Stimulus
de Groot and Schuitema (2012)	–	Experiment	Waste prevention Transportation	UK (convenience)	–	10%–20% vs. 80%–90%	–	A pilot survey indicated that around 10%/90% of a representative sample of the UK population found that this was an acceptable measure for reducing car use.	Article + statement
de Groot et al. (2021)	Study 2	Experiment	Sustainable diet (meat consumption)	The Netherlands (convenience)	20% vs. 80%	–	–	Around 80%/20% of the Dutch population is either trying, or considering to make an effort to limit the amount of meat they consumer.	Article
DellaValle and Zubaryeva (2019)	–	Experiment	Transportation	Italy (convenience)	Increase by 178% vs. control group	–	No social norm appeal No stimulus	South Tyroleans increased in new Electric Vehicle registrations by 178 % in the period 2013–2017.	Ad
Demarque et al. (2015)	Study 1	Experiment	Sustainable consumption	France (students)	9% vs. 70% vs. control group	–	No social norm appeal	For your information, 9% of previous participants purchased one ecological product.	Online shop
Demarque et al. (2015)	Study 2	Experiment	Sustainable consumption	France (students)	1% vs. 9% vs. 70% vs. 90% vs. control groups	–	No social norm appeal	For your information, 9% of previous participants purchased one ecological product.	Online shop
Gossen et al. (2023)	–	Experiment	Sustainable consumption	Germany (quasi representative)	More and more vs. control group	–	No social norm appeal	In collaboration with scientists, we have found that more and more people are extending the life of their mobile phone by getting it repaired.	Online shop
Griesoph et al. (2021)	–	Field experiment	Sustainable diet (meat consumption)	Germany (students)	Positive (44% vegan) vs. negative (56% meat eaters) vs. control group	–	No social norm appeal	On average, 44% of our canteen customers chose a vegan or vegetarian main dish during the last winter term.	Statement
He et al. (2019)	Study 1–3	Experiment	Conservation (energy)	China (students + convenience)	More and more vs. control group	–	Appeal (every student should)	More and more university students set the air conditioning temperature above 26°C in the summer and below 20°C in the winter.	Poster

(Continued)

Table A1 (Continued)

References	Study	Method	Topic	Country	DSNA	ISNA	Control group	Exemplar minority appeal	Stimulus
Kácha and van der Linden (2021)	Study 1–2	Experiment	Pro-environmental behavior	USA (quasi representative)	17% vs. 83%	–	–	17% of other participants have completed the task.	Statement
Kormos et al. (2015)	–	Field experiment	Transportation	Canada (students)	4% vs. 25% vs. control group (no social norm appeal)	–	No social norm appeal	Since 1993, 26% of commuters at [our university] have switched to more sustainable modes of transport to campus vs. only 4% of commuters at [our university].	Statement
Lalot et al. (2018)	Study 1	Experiment	Sustainable consumption	USA (MTurk)	–	18% vs. 82%	–	18% [82%] of the individuals declared supporting the content of the text without hesitation, and committed to make more individual efforts in order to reduce their own consumption. Thus, only a minority [a large majority] of the inhabitants supports unconditionally proenvironmental values.	Article
Lalot et al. (2018)	Study 2	Experiment	Sustainable consumption	Switzerland (students)	–	12% vs. 88%	–	12% [88%] of the individuals declared supporting the content of the text without hesitation, and committed to make more individual efforts in order to reduce their own consumption. Thus, only a minority [a large majority] of the inhabitants supports unconditionally proenvironmental values.	Article
Lalot et al. (2019)	Study 1	Experiment	Waste prevention (recycling)	USA (MTurk)	–	4% to 18% vs. 61% to 82%	–	[Most/Few] Americans are concerned for the environment, view protecting the environment as a top priority, say they try to live in ways that protect the environment; and [a majority/a minority] of Americans do recycle.	Article

(Continued)

Table A1 (Continued)

References	Study	Method	Topic	Country	DSNA	ISNA	Control group	Exemplar minority appeal	Stimulus
Lalot et al. (2019)	Study 2	Experiment	Sustainable consumption	Switzerland (students)	–	12% vs. 88%	–	“12% (88%) of the sampled people declared supporting the content of the text without hesitation, and committed themselves to make more individual efforts in order to reduce their own consumption. Thus, only a minority (a large majority) of the inhabitants.	Article
Lapinski et al. (2017)	–	Experiment	Conservation (water)	USA (students)	3% vs. 90%	–	–	Only 3% of people in the university community took steps to conserve water in the year prior to the study.	Statement
Liu and Lapinski (2024)	–	Experiment	Food waste (students)	China USA (students)	20% vs. 80%	Few vs. majority	–	Only a few of students at XX University, about 20%, have taken actions to help reduce food waste.	Article
Lee and Liu (2023)	–	Experiment	Sustainable diet	USA (students)	35% vs. 35% increased vs. control	–	No stimulus	Recent research has shown that, in the last 5 years, 35% of Americans have now started to make an effort to eat less meat.	Statement
Loschelder et al. (2019)	Study 1	Field experiment	Reusable mugs	Germany (students)	More and more vs. control group	–	No social norm appeal	Our guests are changing their behavior: More and more are switching from the to-go-cup to a sustainable alternative	Sign
Loschelder et al. (2019)	Study 2	Experiment	Reusable mugs	Germany (students)	25% vs. more and more	–	No social norm appeal Behavioral appeal	Our guests are changing their behavior: More and more are switching from the to-go-cup to a sustainable alternative.	Sign
Mortensen et al. (2019)	Study 1	Experiment	Water conservation	USA (students)	48% vs. increase from 37% to 48%	–	Architectural trends	Research from (previous year) has found that 48% of (University name) students engage in one or more of the following water conservation behaviors. This has increased from 37% in (2 years previous).	Statement

(Continued)

Table A1 (Continued)

References	Study	Method	Topic	Country	DSNA	ISNA	Control group	Exemplar minority appeal	Stimulus
Mortensen et al. (2019)	Study 2	Experiment	Donations	USA (MTurk)	48% vs. increase from 17% to 48%	–	No social norm appeal	In July [previous year], 48% of the MTurk workers who took our surveys donated funds to the SEAA. This increased from 17% in July (2years previous).	Statement
Player et al. (2018)	–	Field experiment	Idling engines	UK (convenience)	25% vs. negative (some don't)	–	–	When barriers are down 25% of motorists turn off their engines!	Sign
Reynolds-Tylus et al. (2019)	–	Experiment	Conservation	USA (MTurk)	27% vs. 73% 32% vs. 68%	–	–	27% of Americans take small steps to conserve their water use.	Statement
Richter et al. (2018)	Study 1	Field experiment	Sustainable diet	Germany Norway (convenience)	1% vs. 4% vs. 28% vs. 52% vs. 69% vs. 82% vs. 91%	–	No social norm appeal No intervention	11% of all customers buying seafood in our shop yesterday chose MSC/ASC.	Sign
Rinscheid et al. (2021)	–	Choice experiment	Fossil fuel-powered cars	USA (quasi representative)	Few vs. more and more	–	–	More and more people living in [your state] are buying non-fossil fuel cars and have already started to change their transportation habits, e.g. by using public transportation.	Article + statement
Schorn and Wirth (2023)	Study 1	Experiment	Voluntary carbon offsets	Germany (quasi representative)	Minority vs. increase of 50%	–	No social norm appeal No stimulus	Unfortunately, so far only a minority compensates their CO2 emissions. But there is good news: More and more people are offsetting their emissions.	Video
Schorn and Wirth (2023)	Study 2	Experiment	Voluntary carbon offsets	Germany (quasi representative)	10% vs. 10% increasing vs. none	80% approval vs. none	No social norm appeal No stimulus	Already one in ten people voluntarily offset their flight in 2021. That is five times more people than in the previous year. So there is a positive trend and the proportion is expected to quadruple in the next few years.	Video

(Continued)

Table A1 (Continued)

References	Study	Method	Topic	Country	DSNA	ISNA	Control group	Exemplar minority appeal	Stimulus
Schorn and Wirth (2023)	Study 1	Experiment	Voluntary carbon offsets	Germany (quasi representative)	10% vs. 10% increasing vs. none	80% approval vs. none	No social norm appeal No stimulus	When looking at the German population, already one in ten people voluntarily offset their flight in 2020. This number is five times higher than in the previous year. This is a positive trend, and the proportion is expected to quadruple in the coming years.	Video
Schorn and Wirth (2023)	Study 2	Experiment	Voluntary carbon offsets	Germany (quasi representative)	10% vs. more and more vs. none	80% approval vs. none	No social norm appeal No stimulus	A strong trend is emerging: More and more people are choosing to offset their air travel.	Video
Schultz et al. (2008)	Study 1	Field experiment	Reusing towels	USA (convenience)	25% vs. 75%	Some vs. many	No social norm appeal	Nearly 25% of guests choose to reuse their towels each day. Some of our guests have expressed to us their approval of conserving energy. Because some guests value conservation, this hotel has initiated a conservation program.	Sign
Shealy et al. (2018)	–	Experiment	Sustainable building	USA (convenience)	6-20% vs. 80-95%	–	–	Less than 20 % of Envision projects are able to meet the Restorative level of achievement for this credit.	Statement
Smith et al. (2012)	Study 1	Experiment	Energy conservation	UK (students)	82% vs. 22%	85% vs. 23%	–	Participants were told that 22% of students engaged in energy conservation.	Article
Smith et al. (2012)	Study 2	Experiment	Energy conservation	China UK (students)	82% vs. 22%	85% vs. 23%	–	Participants were told that 22% of students engaged in energy conservation.	Article
Sparkman et al. (2021)	Study 1–2	Experiment	Sustainable diet	USA (MTurk, quasi representative)	More and more vs. control group	–	No social norm appeal	In the US, over six million people have reduced their meat intake, and that number is rising.	Article

(Continued)

Table A1 (Continued)

References	Study	Method	Topic	Country	DSNA	ISNA	Control group	Exemplar minority appeal	Stimulus
Sparkman and Walton (2017)	Study 1–2	Experiment	Sustainable diet	USA (MTurk)	30% vs. 30% (increasing)	–	No social norm appeal	Recent research has shown that, in the last 5 years, 30% of Americans have now started to make an effort to limit their meat consumption.	Statement + visualization
Sparkman and Walton (2017)	Study 3	Experiment	Sustainable diet	USA (MTurk)	30% vs. 30% (increasing; future growth) vs. 30% (increasing; no future growth)	–	No social norm appeal	Recent research has shown that, in the last 5 years, 30% of Americans have now started to make an effort to limit their meat consumption. [...] This trend is expected to continue in the near future.	Statement + visualization
Sparkman and Walton (2017)	Study 4	Field experiment	Sustainable diet	USA (students)	30% vs. 30% (increasing) vs. description of an off-topic trend (control group)	–	No social norm appeal	Specifically, recent research has shown that 30% of Americans make an effort to limit their meat consumption. That means that 3 in 10 people eat less meat than they otherwise would.	Statement
Sparkman et al. (2020b)	Study 1	Field experiment	Sustainable diet	USA (convenience)	Dynamic vs. control group	–	No social norm appeal	Our Meatless Burgers Are on the Rise. We’ve noticed customers are starting to choose more meatless dishes.	Sign
Sparkman et al. (2020b)	Study 2–4	Field experiment	Sustainable diet	USA (convenience)	Dynamic vs. control group	–	No social norm appeal	We’ve noticed that customers are starting to eat less meat by choosing more meatless dishes.	Sign



OPEN ACCESS

EDITED BY

Giuseppe Carrus,
Roma Tre University, Italy

REVIEWED BY

Dimitrios Xenias,
Cardiff University, United Kingdom
Yue Ting,
China University of Mining and Technology,
China

*CORRESPONDENCE

Robert Tobias
✉ robert.tobias@uzh.ch

RECEIVED 30 May 2024

ACCEPTED 30 September 2024

PUBLISHED 15 October 2024

CITATION

Tobias R, Moraz N and Degenhardt B (2024)
Applying a new theoretical and
methodological approach for
behavior-change campaign planning:
identifying the critical determinants for
reducing littering and evaluating the resulting
large-scale campaign.
Front. Psychol. 15:1441094.
doi: 10.3389/fpsyg.2024.1441094

COPYRIGHT

© 2024 Tobias, Moraz and Degenhardt. This
is an open-access article distributed under
the terms of the [Creative Commons
Attribution License \(CC BY\)](#). The use,
distribution or reproduction in other forums is
permitted, provided the original author(s) and
the copyright owner(s) are credited and that
the original publication in this journal is cited,
in accordance with accepted academic
practice. No use, distribution or reproduction
is permitted which does not comply with
these terms.

Applying a new theoretical and methodological approach for behavior-change campaign planning: identifying the critical determinants for reducing littering and evaluating the resulting large-scale campaign

Robert Tobias^{1*}, Nicole Moraz¹ and Barbara Degenhardt²

¹Social Psychology, Department of Psychology, University of Zurich, Zurich, Switzerland, ²Irchel Campus Usage Management, University of Zurich, Zurich, Switzerland

Introduction: This paper presents a theoretical concept and methodological approach for identifying critical determinants for behavior change interventions. The approach is based on established theories and constructs but represents them in an intervention- instead of questionnaire-oriented form. Six discriminant and targetable dimensions of behavior determinants are proposed: Consideration, feasibility, instrumental evaluation, norms and goals, affective evaluation, and needs and tension states.

Methods: For estimating the importance of these dimensions for a specific behavior to be changed in a specific situation and population, a quasi-experimental approach is proposed, in which interventions are designed to have effects on one of these dimensions but none on the other dimensions. By measuring changes of the target behavior or its consequences, the impact of each dimension on changing the behavior can be estimated *in-situ* without questionnaires. The approach was applied to develop a campaign for reducing picnic littering in an urban park in Zurich (Switzerland). In 2019, posters targeting four dimensions were set up during three waves in up to four zones with two control zones without posters. Before, between, and after the intervention waves, for at least 2 weeks, no interventions were in place. The volume of litter was measured on 119 days at 55 points.

Results: In some cases, the amount of litter was too small for effects to be detected, but where enough littering occurred, posters providing information, inducing positive emotions, or activating reciprocity norms—as well as providing the option of separating fractions of waste for recycling as a structural measure—reduced litter significantly. Interventions targeting the tension state of disgust had no effect. Posters targeting descriptive and injunctive norms increased the amount of litter.

Discussion: Based on the results of the preparative study, a large-scale campaign was designed, implemented, and evaluated in 2022, which led to promising effects.

KEYWORDS

littering, pro-environmental behavior, behavior change, intervention, quasi-experiment/field study, parks/trails, behavior determinants, information campaign

1 Introduction

Based on decades of psychological research, it is well documented what hinders people from changing problematic behaviors, and what behavior-change techniques could be applied in principle. However, it turned out to be difficult to apply this accumulated knowledge on behavioral determinants, mediators and moderators to specific real-world settings or interventions. That is, general recommendations about when to apply which technique in what form has shown not being enough to deal with the complexity and dynamics of real-world problems. Tools are required that—based on scientific evidence and empirical data, and considering the challenges of applied settings—help determine barriers of and design behavior-change techniques for specific situations, populations, and behaviors (c.f. [Michie et al., 2011](#); [Weaver, 2015](#)). In this paper, we will present, apply, and discuss a new approach that serves this function, using the example of littering.

The impact of litter (i.e., misplaced solid waste, [Geller, 1980](#)) is dramatic on many levels. As an environmental problem, it directly harms wildlife and humans alike. For example, it can cause injuries, poisoning, attract vermin, or decompose to dangerous substances ([Berger et al., 2008](#)). But as with most environmental problems, littering can also have economic impacts. For example, it creates aesthetic issues ([Pandey, 1990](#)) that reduce the recreational and property value of affected areas ([Skogan, 1990](#)). Even social problems can be exacerbated by littering. Litter has a symbolic effect indicating the absence of care and the acceptance of transgressions, which can lead to an increase in social transgressions like theft ([Keizer et al., 2008](#)).

Litter causes so many problems that the reduction of littering was one of the first topics of environmental protection psychology, which started in the sixties, and much research was done to inform litter prevention programs ([Burgess et al., 1971](#); [Cone and Hayes, 1980](#); [Geller et al., 1982](#)). In a systematic review, [Chaudhary et al. \(2021\)](#) identified 70 articles on littering behavior published between 1971 and 2018. A summary of this research is also provided by [Schultz et al. \(2013\)](#). They identified three approaches to littering research: (1) the search for the demographic characteristics of people who litter, (2) the effect of the physical context on littering behavior, and (3) the analysis of what is littered.

Early investigations into psychological processes behind littering mostly focused on normative signals of the situations in which littering happens, such as litter that is already present ([Cialdini et al., 1990](#)) or how ‘disordered’ the setting is ([Keizer et al., 2008](#)). The conclusion drawn from these studies was that litter can best be prevented by conveniently placing garbage bins and removing any litter as quickly as possible ([Schultz et al., 2013](#); [Van Doesum et al., 2021](#)). This ‘solution’ is, however, often not satisfying. More frequent

cleaning and providing more garbage bins—which need to be emptied—can be more costly than collecting more litter. Furthermore, a larger number of conveniently placed garbage bins may reduce the recreational value of a landscape (e.g., [Van Doesum et al., 2021](#)).

According to [Schultz et al. \(2013\)](#), only 15% of all littering acts result from contextual variables. Therefore, littering-reducing measures that target psychological processes might be a more efficient approach to solve the littering problem. Such interventions require a deeper understanding of these psychological processes. One approach to investigating psychological processes is with questionnaires (e.g., [Ai and Rosenthal, 2024](#); [Mori et al., 2024](#); [Oduro-Appiah et al., 2024](#); [Ojedokun et al., 2022](#)). The most influential constructs in questionnaire-based studies are related to normative evaluations and the awareness of consequences or ascription of responsibility. However, while survey-based investigations allow a precise assessment of psychological constructs and can be informative for the investigation of many behaviors, in the case of littering, such data has a limited value. Not only is littering a socially undesired or even illegal behavior, for which strongly biased answers must be expected. More importantly, most forms of littering are not a result of deliberate decisions. Still, people can be aware of the behavior and conscious about their decision in the situation. But people might not reflect on their reasons and therefore not be able to explain what happened in the situation. We must assume that retrospectively assessed reports are constructed in the moment of answering the questionnaire items and not necessarily reflect the processes determining the behavior in the situation. This is well-illustrated by [Hansmann and Steimer's \(2017\)](#) study where participants provided very different reasons for their own littering and the littering of other people. Also, in the study of [Farage et al. \(2021\)](#), the littering-avoidance intention, which was assessed with questionnaire items, could be explained well, while the observed littering could not be explained.

For a behavior that cannot be investigated well with questionnaire data, experimental methods are indicated. However, experiments in the laboratory are also problematic. Littering usually has a strong situational component, making it difficult to extrapolate from laboratory or online settings to the real world. Therefore, we conclude that field experiments with interventions on various psychological processes and measurement of the actual littering (e.g., [Gangl et al., 2022](#)) lead to the most valid information on how littering can be reduced. This form of investigation is, however, sparse ([Chaudhary et al., 2021](#)). Furthermore, often artificial forms of littering, such as distributed flyers (e.g., [Hansmann and Steimer, 2016](#)), are used that might not well represent natural occurring littering.

The present study starts from this idea of investigating the psychological processes driving littering or rather littering reduction with field experiments. The goal is to identify the psychological constructs or processes that are most promising to be targeted in a large-scale anti-littering campaign—to generate an empirical basis for designing anti-littering measures for a specific location and population and develop the intervention material with this empirical basis. For such an endeavor, several research gaps need to be tackled.

First, littering behavior needs to be better specified from a psychological perspective. While from an environmental perspective, the critical aspects are what is littered where, from a psychological perspective, litter is a consequence of a variety of behaviors that can have different psychological characteristics. This paper proposes a

Abbreviations: AE, intervention to increase positive emotions (on the dimension of Affective Evaluation); AE-IE, intervention to increase positive emotions and on knowledge (on the dimensions of Affective Evaluation and Instrumental Evaluation); CI, Confidence Interval; HAPA, Health Action Process Approach ([Schwarzer, 2008](#)); IE, Intervention on knowledge (on the dimension of Instrumental Evaluation); L, Litter; NAM, Norm Activation Model ([Schwartz, 1977](#)); NGdi, Intervention on descriptive and injunctive norms (on the dimension of Norms and Goals); NGr, Intervention on reciprocity norms (on the dimension of Norms and Goals); NT, Intervention on disgust (on the dimension of Needs and Tension states); TPB, Theory of Planned Behavior ([Ajzen, 1991](#)).

rough classification of some forms of littering and specifies the type of littering investigated.

Second, psychological constructs are mainly specified by questionnaire items and for many, it is difficult to design manipulations that target all facets of the construct without affecting other constructs. Therefore, the present paper will propose a theoretical concept that represents established psychological constructs from an intervention instead of a questionnaire perspective.

Third, most studies that investigate littering behavior stop with quantifying effects. However, it is still a huge step from such results to a large-scale campaign. This paper exemplifies, for a specific case, how results of a scientific study can be used to develop a campaign—and estimates the effect of such an intervention, considering the limited resources available in non-scientific projects. Finally, this paper adds to the growing body of evidence on psychological determinants of littering and litter-avoidance behavior and presents the effects of a large-scale litter-reduction campaign.

2 Theoretical background

2.1 Behavior specification and study approach

The many behaviors that can lead to misplaced solid waste can be driven by very different psychological processes. Therefore, for designing psychological measures, it is necessary to specify what behaviors shall be changed. Personal site inspections and interviews with the Operational and Security Services revealed that four types of littering were prevalent in the investigated park: (1) Careless disposal of small pieces of garbage, particularly cigarette butts. This form of littering is strongly determined by habits, and campaigns targeting such behavior need to focus on measures to prepare for or change the situations where such behavior could potentially happen (e.g., providing more ashtrays, which also serve as memory aids). (2) Leaving behind garbage after a prolonged stay at a place, e.g., after a picnic. This form of littering can occur for a variety of reasons, but measures targeting such behavior should have a direct effect, because the interventions used can be perceived and processed before littering is irreversible. (3) Particularly at night, parties are common in the park that often result in larger amounts of litter. While the causes for this form of littering can be like for picnic littering, further factors might play a role. In some cases, littering might be intentional to demonstrate rejection of norms or show the world how wild the party was. In other cases, people might have been so intoxicated that they were unable to clean up even if they had intended to do so. (4) The park is sometimes also used to dispose of larger amounts of garbage from households or even construction sites. This is finable and, due to its different legal status, such behavior is often not considered littering but illegal garbage disposal.

For this study, the second form of littering ('picnic littering') was selected because measures to change such behavior are easier to implement and picnic littering is easier to measure: It can be (mostly) isolated from careless litter disposal by limiting the measurement of litter to places where people stay longer. Picnic littering can also be separated from party littering by limiting the measurement to the afternoon because the park is cleaned early in the morning and parties happen mostly at night.

Once the to-be-changed behavior is specified, the main task is to identify the psychological processes that should be targeted to induce the desired changes most efficiently. In many cases, a survey that assesses psychological constructs, the behavior, and further information could be used. However, for campaign planning, surveys have several disadvantages. Particularly, it is difficult to reach even a roughly representative sample of the target population and the relation between questionnaire data and intervention effects is only based on theoretical assumptions—not to speak of possible biases in the questionnaire answers. In the case of poorly reflected behavior decisions, such as we assume for littering, little useful information can be deduced from questionnaire data. Neither do people elaborate much about the decisions to leave waste behind, nor do they remember what drove their behavior, when asked about it later. We expect the answers to be mostly defensive post-hoc rationalizations, such as a supposed lack of garbage bins.

Therefore, within the development of a real-world campaign to reduce behaviors such as littering, a quasi-experimental field study appears to be the best approach. It allows identifying critical psychological processes without questionnaires, in the specific situation and representatively from the target population. To avoid ethical issues, ideally, such an approach also omits direct observations of the behavior. Of course, field experiments come with their own set of challenges, particularly the limited controllability of the situation and participants. Effects could be moderated by unknown situational influences and experimental manipulations could have effects in other zones than they were installed. Such factors need to be considered in the interpretation of the data.

To conclude, the basic idea of the approach presented here is to conduct a quasi-experimental field study with (a) a systematic variety of interventions and (b) measure behavioral effects, i.e., the amount of litter, as outcome variable. Each intervention is designed to target only one psychological process or class of similar processes that are assumed to be determinants of the investigated behavior. From the comparison of the effects of these interventions, the relevance of each process for reducing littering can be derived.

2.2 Psychological determinants of behaviors

Psychology offers many theories and models to explain individual behaviors, such as the Theory of Planned Behavior (TPB; [Ajzen, 1991](#)), the Health Action Process Approach (HAPA; [Schwarzer, 2008](#)), or the Norm Activation Model (NAM; [Schwartz, 1977](#)), to name a few (*cf.* [Hagger et al., 2020](#); [Rau et al., 2022](#)). Many researchers extended or combined the mentioned models (e.g., [Bamberg, 2013](#); [Klößner and Blöbaum, 2010](#)). However, on the abstract level as the concepts are discussed here, these models use the same psychological constructs. Therefore, in the following, we mainly refer to the constructs of the first three models. All these models proved valuable in multiple questionnaire-based studies and applications, however, many of their constructs cannot be used in an intervention-oriented approach as presented here.

First, many constructs are defined in overly general terms comprising several processes at once. For example, attitudes of the TPB comprise cognitive and affective processes, and outcome expectations of the HAPA even normative aspects, which are all different regarding

their effects on the behavior and the form of interventions targeting them. For our study, it is necessary to separate processes that require different forms of interventions (cf. Hagger et al., 2020; Rau et al., 2022).

Second, between the models, differences of the constructs are often too subtle for interventions to be distinguished (cf. Hagger et al., 2020). For example, it would be almost impossible to design an intervention that changes perceived behavior control (a TPB construct) but not self-efficacy (a HAPA construct). Therefore, if constructs are specified by the type of interventions instead of wording of questionnaire items, such similar constructs are assumed to represent the same psychological process.

Third, each behavior model was designed with a specific perspective and thus, abstracts from certain processes that are not in the models' focus. Particularly, processes that are difficult to assess by questionnaire (e.g., tension states) or that were assumed to be irrelevant due to the design of the studies testing the models, (e.g., consideration of the behavior), are often omitted. To have an optimal basis to select interventions, we will consider such psychological processes—at least as processes that should not be affected by interventions on other processes.

To guide the design of such specific interventions, we propose a set of dimensions of (social-) psychological behavior-determining processes (see Figure 1) derived from established behavior models, partially by abstraction and partially by specification. The idea is to group together psychological processes that are similar regarding the form of interventions targeting them, and separate processes that are different and often conflict with the processes of other dimensions. So, these dimensions are not single constructs, but classes of psychological processes. For a specific investigation, constructs and interventions targeting them need to be specified (e.g., monetary costs or injunctive norms). These constructs never cover an entire dimension of processes. However, not only can many constructs/interventions be specified within a dimension, but they can also cover several dimensions—such as attitudes or most interventions in real-world behavior-change campaigns. Such multi-dimensional interventions would, however, not be suitable for the study approach explained above.

This space of psychological determinants of behaviors is not meant to replace any behavior model. The main goal is to support the reflection of possible barriers of behavior change within a complex applied problem. Even if working with established constructs and measurement tools, for selecting them, one first needs to realize in more general terms, what could influence a behavior. The selection of investigated constructs and, thus, measurement tools should be based on a solid analysis of the problem and not, as is often done, the problem squeezed into a form that allows investigating the favored constructs. Within the approach presented in this paper, such general space of determinants is particularly essential, because not only the processes targeted by the interventions need to be specified, but also what processes *must not be affected* by these interventions. While it is impossible to specify all constructs that shall not be affected by an intervention, a rough system of dimensions allows designing focused interventions to inform the development of real-world campaigns.

We propose six dimensions of processes involved in behavior selection, which open two distinct spaces, one of two dimensions—the pre-conditions of behavior execution—and one of four dimensions—the evaluation of behavior execution (Figure 1). The pre-conditions consist of *consideration* and *feasibility*. For a behavior option to be evaluated, it must be considered (i.e., known, remembered, and seen

as adequate in a specific situation). Consideration does not require consciousness, neither of the behavior options, nor of the process of selecting an option. This becomes particularly apparent in the case of habits which, according to Tobias (2009), act also on consideration: If we have a strong habit for a behavior in a specific situation, we might enact it without even remembering having done such action. However, the habit led to considering the selected option. Besides investigations into prospective memory (e.g., McDaniel and Einstein, 2007), in most models explaining behavior, such as the TPB or the HAPA, consideration is either not separated from feasibility or not considered at all. Most studies assume consideration of the behavior under investigation as a given. However, knowledge about how to perform the behavior or about the behavior's consequences are often investigated and targeted in studies and campaigns (e.g., Hossain et al., 2022; Liu et al., 2020).

Feasibility is found in most behavior models in one or another form, representing a perceived external situational factor that makes a behavior more or less difficult or controllable to perform (c.f. perceived behavior control in the TPB; self-efficacy in the HAPA). However, these constructs are conceptualized differently than in our approach, mainly representing any situational effect that might lead to a discrepancy of a previous evaluation (resulting in an intention) and the actual behavior performance. In contrast, in our approach, any dimension of behavior determinants can be personal or situational (or related to the population¹). Feasibility is conceptualized as the perception that a behavior is possible to perform. This is distinguished from the effort to perform a behavior, which is part of the evaluation explained later. For example, if people form their intentions of the travel mode to use for commuting, they might deem public transportation not feasible, because there exists no public transportation at their location. Here, feasibility acts as a personal barrier to using public transportation. However, if they have public transportation options, but deem them too expensive or time consuming to use, it would not be feasibility, but rather instrumental evaluation (see below) that acts as a personal barrier. Equally, feasibility as well as instrumental evaluation can act as situational barriers. If a person usually travels by public transport but, on one day, it is cancelled, using this travel mode is considered not feasible in this situation. Or, this person wants to get home faster, one day, and, thus, instrumental evaluation acts as a situational barrier to using public transportation. In most established behavior models, in the situation, no distinction between feasibility and evaluations is made and all situational influences subsumed in constructs, such as low perceived behavior control or self-efficacy. In contrast, here, the same distinction between feasibility and evaluation is made for barriers when forming the intention or when performing the behavior.

1 Within this investigation, we only consider processes in the situation of the behavior selection (i.e., when a behavior is performed or not). If barriers to behavior change are personal, more enduring knowledge, beliefs, opinions, values, etc. need to be changed. Barriers related to the population hinder behavior change due to unfavorable dynamics in the target population, for example, a lock-in due to nobody wanting to be the first to change the behavior, even though most people would prefer a change in behavior. Further, barriers to behavior change can also be structural, mainly due to rules (e.g., laws), economic conditions (e.g., prices), or the provision of infrastructure and services (e.g., lack of garbage bins).



Behavior options that a person considers and deems feasible are evaluated in a space of four dimensions: (1) instrumental evaluation, (2) norms and goals, (3) affective evaluations, and (4) needs and tensions states. *Instrumental evaluation* expresses the extent to which performing a behavior is worthwhile, considering costs and benefits. This dimension comprises resources such as money and time, but also consequences of the behavior, for example, for health or the environment. Such cost–benefit evaluations are found in most psychological models for explaining behaviors, but mostly they are combined with other dimensions proposed here. For example, the attitudes of the TPB comprise instrumental and affective aspects (Breckler and Wiggins, 1989). The outcome expectations of the HAPA comprise all consequences of performing a behavior, not only instrumental, but also affective and normative (Schwarzer, 2008). Instrumental evaluation depends strongly on an individual's mental models related to the behaviors. For example, how behavior performance impacts the environment or who is responsible for doing something about it. Thus, instrumental evaluation comprises processes related to comparisons of advantages and disadvantages of behavior options and their consequences.

(2) *Norms and goals* comprise the references to which individuals compare behaviors and behavior consequences. Many theories consider norms referring directly to the behaviors, such as descriptive and injunctive norms (Cialdini et al., 1990). They express how many others are observed or perceived performing the behaviors (descriptive norms) and how good or bad other people perceive the behaviors (injunctive norms). For the NAM, norms are the main drivers of behaviors. In the TPB, such norms are considered as construct in their own right (subjective social norms, Ajzen, 1991), while, in the HAPA, they are a part of the outcome evaluations (Schwarzer, 2008). Another norm considered in our study is reciprocity: People feel obligated to return a favor (Johnson et al., 1989). However, norms are not the only constructs used as reference to evaluate behaviors and their consequences. The goals a person pursues are also important (Brandstätter and Bernecker, 2022). Norms and goals also comprise symbolic functions of behaviors—in the sense of Dittmar (1992) for material possessions—which means that some behaviors are not only done for their instrumental consequences, but also for the meaning they express (e.g., driving a large car to appear as rich and powerful, Wicklund and Gollwitzer, 1981). To conclude, norms and goals comprise processes of evaluating the fit of behavior options and their consequences to references in the social environment or own standards.

Instrumental evaluation and norms and goals require a certain level of deliberation. However, some evaluations can be done almost spontaneously, such as (3) the *affective evaluation*. This dimension expresses how much a person feels like doing the behavior or perceives the behavior execution as pleasant or annoying. Most theories do not consider affective evaluation as an individual factor and combine it with instrumental evaluation (e.g., attitudes in the TPB or outcome evaluations in the HAPA). However, instrumental evaluation and affective evaluation are based on different psychological processes, show different dynamics (e.g., affective evaluation fluctuates faster and depends more on situational influences), and often lead to antagonistic evaluations (e.g., taking garbage to the garbage bin might be annoying with reference to affective evaluation, but better for the environment with reference to instrumental evaluation). Affective evaluation cannot be changed with arguments but mainly builds on emotional experiences and their associations with behaviors, forming affective connotations of these behaviors. However, behaviors can also have intrinsic characteristics that make them more or less enjoyable to perform. Based on this, behaviors can also serve affective functions and are performed, for example, to improve one's mood or relax and reduce stress (Degenhardt and Buchecker, 2012; Gatersleben and Steg, 2013). Therefore, affective evaluation comprises processes of experiencing a desire or aversion to performing a behavior. For the behavior selection, particularly the feelings experienced when thinking about the behavior options before and while selecting them are critical. Note that expected emotions are rather part of the instrumental evaluation (or between the instrumental and affective evaluation), because expected emotions are not experienced but considered as an advantage or disadvantage of performing a behavior.

The last evaluation dimension, (4) *needs and tension states*, is rarely considered as its own factor in models, studies, or campaigns, but rather combined with affective evaluation. However, regarding psychological processes and behavior-change techniques, there are important differences between these two dimensions. While affective evaluation determines behavior selection mainly when no other 'good reasons' for doing something exist, needs and tension states have a strong motivating aspect that can push people towards performing or avoiding certain behaviors. Needs and tension states comprise all 'strong feelings' (many of them can be assessed as specific emotions) that go beyond a mere valence on a scale of pleasant to unpleasant and are perceived as pushing towards or away from a behavior. These can be based on physical needs (e.g., hunger or strain), perceptions of the world (e.g., fear, guilt, disgust, dissonance, reactance, anger, envy,

shame, or injustice), or be provoked intentionally (e.g., with an implementation intention; Gollwitzer and Sheeran, 2006) to align the situational behavior selection with strategic evaluations and goals. Most of these tension states form research topics of their own. For the present study, disgust is of particular interest (e.g., Auger and Curtis, 2013; Curtis et al., 2004). Regarding behavior change techniques, affective evaluations can only be changed by emotional experiences related to the respective behavior. In contrast, tension states can also be changed by targeting cognitive processes with information and arguments.

All these dimensions are on a high level of abstraction and for each case, they need to be further specified. As already mentioned, within instrumental evaluation, costs of money and time or consequences for the environment or health could be important. Equally, within norms and goals, descriptive, injunctive or reciprocity norms could be distinguished. Which further specifications are used, distinguished, or combined depends on the requirements of each case. Often, however, despite the subtle differences, the psychological processes involved might be similar. Saving time might be done to save money, information about descriptive norms might be interpreted as an indicator for what people actually think is the right thing to do, etc. Of course, barriers are often formed from several dimensions and, for behavior-change campaigns, interventions mostly target various dimensions. However, for identifying the critical dimensions as basis for planning a campaign, interventions are required that target only one dimension.

Applying this intervention-oriented specification of behavior determinants to the approach presented in the previous sub-section (2.1), we can investigate the role of each determinant without using questionnaires. By applying manipulations that target only one dimension and affect other dimensions as little as possible, a field experiment can be used to estimate the role of each dimension for reducing littering. The effect of the interventions on the measured behavior or its consequences (e.g., amount of litter) indicates the importance of the respective dimension for changing the behavior. This method was used in preparation of a large-scale anti-littering campaign in an urban park in Zurich, Switzerland. The proposed intervention-oriented specification of established constructs should not be understood as a new theoretical model, but as a tool that makes the knowledge compiled in established behavior models better accessible to the design of campaigns. Therefore, this study does not present hypothesis tests but investigates how the proposed approach is useful for the design of campaigns. Of course, a single study is just a first step of such investigation and further applications of the proposed approach would be required to build confidence in the utility of the method.

3 Preparative investigation

3.1 Materials and methods

3.1.1 Site and participants

The investigation was done in the 'Irchelpark', an urban park in the north of the City of Zurich, Switzerland, with an extension of about 800 × 600 m (see Figure 2). This park was created in the 1980s as a nature-oriented recreational area and surrounds one of the campuses of the University of Zurich. While officially not a part of the university, maintenance of the park is done by

personnel of the university. Due to its location, the park is highly frequented by a wide range of users, including students, inhabitants of the surrounding residential areas, people from the surrounding offices having a break, families making a picnic or barbecue, groups of adolescents throwing parties, and homeless people. The park has several ponds, offers options for sports, provides important transit routes for pedestrians, and frequently hosts large events. The park is also frequented by animals, including large birds and foxes, as one side continues into the woods, is relatively protected from the urban noise, and suffers from minimal light contamination.

In 2018, Irchel Campus Usage Management initiated a joint initiative with the university's Operational Service unit that cleans the Irchelpark and the Chair of Social Psychology to develop measures for reducing littering in the Irchelpark. The size and strong segmentation of the park made the site well suited for the presented approach, as similar but clearly separated zones could be specified. In late 2018, project financing was secured, and the first part of the project—the investigation of the critical psychological dimensions—was designed and organized from the winter of 2018 to the beginning of 2019. Data gathering took place from May 6 to September 29, 2019, which comprised almost the entire warm period of that year. Unfortunately, the weather in May 2019 was unusually cold and wet, so, in the beginning of the study, the park was not visited often.

3.1.2 Experimental manipulations

The experimental manipulations consisted of 1.2 × 0.8 m and 0.8 × 0.6 m large posters (Figure 3). If an intervention was active, according to the size and visibility within the zones, one to three equal posters were set up. From any position within a zone, at least one poster was visible. Each poster type targeted a specific dimension of behavioral determinants or, in one case, a combination of dimensions. The goal was to maximize the effect on one dimension of determinants and, at the same time, minimize the effect on all other dimensions.

The posters were created by a professional designer in close cooperation with the research team to guarantee the correct psychological effects. The theme of the campaign—sketched by the second author—are anthropomorphized garbage bins. The facial expressions were designed to convey much information, even without the viewer understanding the text but the figure did not have arms, so that the observer remains the only actor who can place waste in the bins.

While much of the message of the posters could be conveyed graphically, some posters required a larger amount of text to better specify and clarify the message. The text was provided in German, which is the official language of Zurich and the dominant language of the park visitors. Key words were highlighted allowing the message to be captured in less than a second. The posters comprised a QR-code that linked to the project page. There, general information about the project was provided, but no specific information about the posters.

Figure 3 presents all types of posters used in this study. The poster targeting instrumental evaluation (IE) conveys information about why littering is problematic. It states in German: "Did you know? Garbage outside the garbage bin is a threat to humans and animals – even if it is packed because animals can scatter it. Please always dispose of garbage in the garbage bins. Thank you!"

Two posters were used targeting norms and goals. NGdi activates descriptive and injunctive norms ("Glad you are part of it! 4 out of 5



FIGURE 2

Study site (Irchelpark, source: Google Maps) with the investigation zones (photos by first author).

guests of Irchelpark dispose of their waste in the waste containers and would like others to do the same.”), NGr targets the reciprocity norm (“For you we clean the park – 4h a day. Thank you for the time you gave us by disposing of trash in the garbage bins. University of Zurich, Operational Service”). The information provided on these posters is based on a survey with park visitors in August to October 2018, and on information provided by the Operational Service.

The poster targeting the affective evaluation (AE) states: “Please do not waste any garbage! Feed our hungry garbage bins!” The idea was to put the observer in a positive mood with a funny message and, by doing so, help overcome the reluctance to carry the garbage to the garbage bin. This intervention is like the one used by [Hansmann and Scholz \(2003\)](#). To distinguish the effect of this poster from others, no meaningful information or reason is provided for the target behavior.

Regarding needs and tension states (NT), we focused on disgust. The idea was that the observers should dispose or pack material that, later, might become disgusting to touch. The message was: “Be faster! Dispose or pack your waste *before* the disgust comes.” While this poster, in the first place, provides information, it is expected to reduce experienced disgust and, therefore, affects the dimension of needs and tension states.

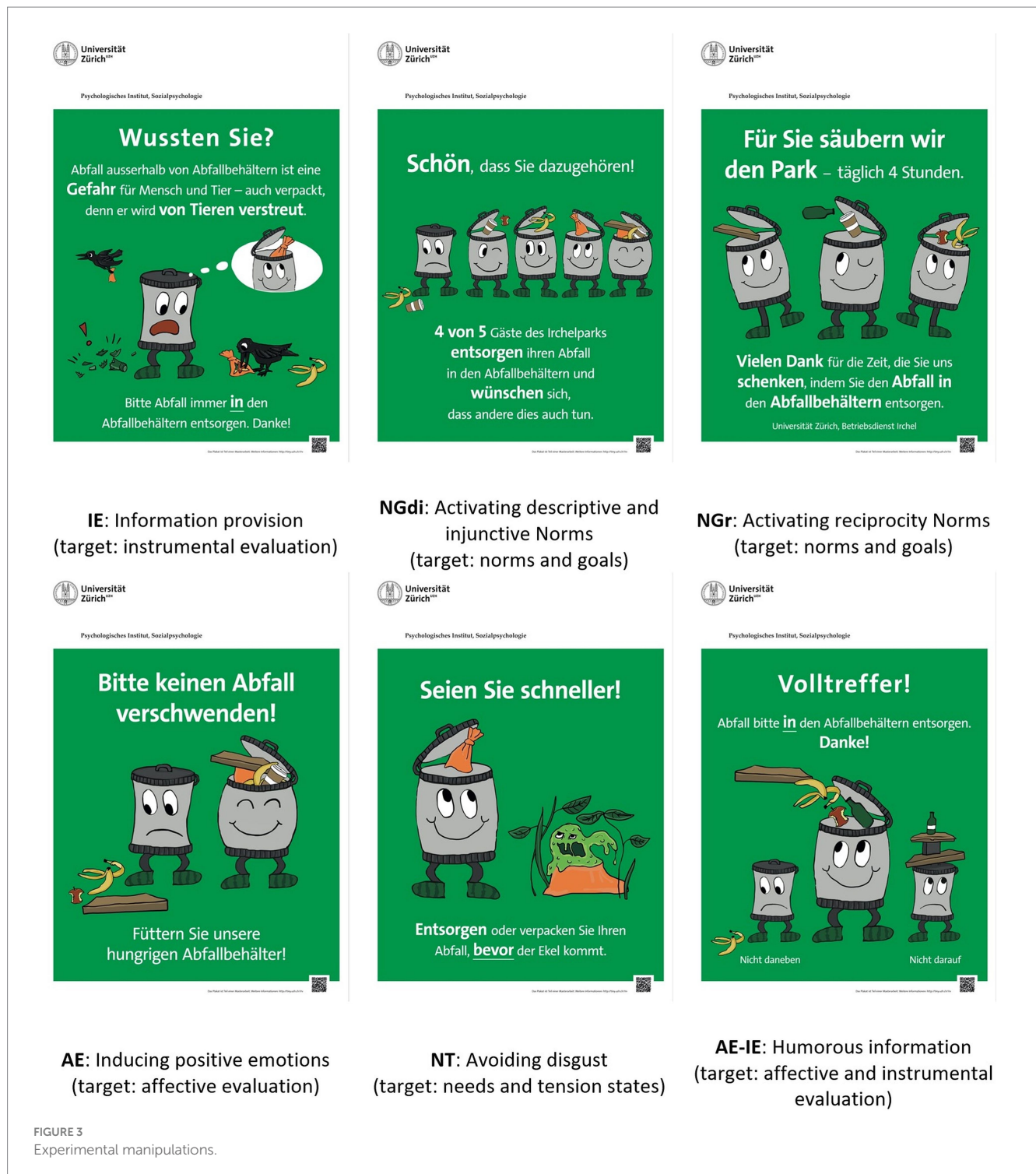
These five posters comprise the manipulations to provide the information for planning the large-scale campaign. In parallel to this preparative study, in Zone 7, an actual intervention with the goal to maximize behavior change was implemented. Therefore, the intervention in this zone does not follow the approach used for the rest of the preparative study. We include it in this paper, because it provides examples for a structural intervention, an intervention that targeted feasibility, and a poster design that targeted multiple dimensions to maximize the effect.

The problem targeted in Zone 7 was that cardboard, particularly pizza boxes, were often put beside or above the garbage container. We assumed a possible reason for this is that people would like to separate cardboard for recycling, as they do at home. So, as a structural measure targeting feasibility, affordances in the form of a second container only for cardboard was provided and/or the Poster AE-IE was used. The poster stated: “Bull’s eye! Please dispose of waste *in* the waste garbage container. Thank you. Not next to it. Not on top.” This poster targets affective evaluation with the humorous eyecatcher, but by more specifically explaining the behavior, it also targets instrumental evaluation. We targeted these two dimensions, because we deemed it necessary to explain the behavior (IE), and previous research indicated that humorous prompts are more effective ([Hansmann and Steimer, 2016](#)). When two containers were placed, they were further clearly marked ([Figure 4](#)).

No intervention on consideration was implemented within this study. Due to the large number of garbage bins and the posters, when in place, forgetting as cause of littering can be ruled out. However, forgetting can be a critical factor for other behavior-change campaigns when such natural memory aids do not exist (e.g., [Tobias, 2009](#)).

3.1.3 Experimental plan

The design of the preparative study is a between-subject longitudinal study with a rolling sample. The park was divided into seven investigation zones, as marked in [Figure 2](#). These zones were isolated by ridges and vegetations, so that it was not possible to see the posters from other zones, when standing in one zone. These topographic features of the park limited the number of zones that could be specified for this investigation. It cannot be ruled out that people heading to a picnic spot passed through other zones and, thus,



might have been influenced by the posters of these zones. However, the zones were specified in a way that no other intervention zone had to be crossed if individuals used the shortest route from the nearest park entrance to the respective zone. If the different interventions would have been confounded, it would have reduced the observed effects for all posters.

The design of the study (Table 1) comprises three intervention periods of 3 weeks, each. In-between the intervention periods, 2 weeks, and, before and after, 3 weeks without interventions were planned. However, due to bad weather, the baseline period was prolonged to

6 weeks. Due to the design of the analyses, this has no influence on the results, because all zones were affected equally from these conditions.

During the intervention periods, some zones remained without interventions to serve as control zones. Therefore, besides the special case of Zone 7, only in three (in the last period four) zones, interventions were applied—despite having five different interventions to apply. Consequently, not all interventions could be applied in one period. To control for effects of the period, in which an intervention was applied (e.g., due to varying weather conditions), and for differences in the zones (e.g., due to varying numbers and types of



FIGURE 4
Structural measure: Second container to separate cardboard with signs ‘garbage in here’ and ‘cardboard in here’ (photo by first author).

TABLE 1 Experimental plan.

	Week	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
May	19							
	20							
	21							
	22							
June	23							
	24	Control	IE	NT	Control	Control	AE	Structural measure
	25							
	26							
July	27							
	28							
	29	Control	NGdi	NGr	Control	Control	IE	Structural measure and AE-IE
	30							
	31							
August	32							
	33							
	34	Control	NT	AE	NGdi	Control	NGr	AE-IE
	35							
September	36							
	37							
	38							
	39							

The intervention abbreviations (e.g., IE) refer to the manipulations presented in Figure 3.

visitors), effects were always compared to the control zones of the same part of the park as the respective intervention zones.

All interventions were applied twice, but never in the same zone or phase (except for the interventions in Zone 7) to avoid confounding effects with characteristics of the zone or phase. While this design controls for biasing influences as much as is possible in the field, still certain confounding conditions cannot be excluded. Particularly, order effects are possible. For example, a very effective intervention might reduce littering so much that a following intervention cannot reduce littering anymore and, thus, appears to have no effect—or the effect of a following intervention might only result due to the intervention that was applied before. This will be considered in the interpretation of the results.

3.1.4 Data gathering

All analyses presented here are based on ‘objective’ measurements of litter, avoiding problems with subjective assessments of the amount of litter or dirtiness of a place. Every day—except in particularly bad weather when almost no one was present in the park (28 out of 147 days)—litter was measured, starting late afternoon. Because picnic littering happens mainly from noon to the evening and the park is cleaned in the morning, litter measured in this period should include most of the picnic littering but exclude most party littering, which occurs mostly at night.

Litter measurement followed a strict protocol: In each of the zones (see Figure 2), 3 to 16 measurement points were specified, and, whenever litter was measured, all 55 measurement points were considered. The measurement points were kept unchanged for the entire study and were defined based on locations where littering behavior was expected. We selected every garbage bin in the zone (to measure garbage deposited outside the bin), and locations where people tend to stay longer time (e.g., benches). At each measurement point, the students who did the measurement specified one square meter—the one with most litter or the one they checked previously—and collected all garbage within this square meter. So, which square meter was searched for garbage changed over time but was always within the area of the pre-defined measurement point. For example, a measurement point could be a bench. On 1 day, the students might have collected garbage from a square meter on the table, on another day, the square meter might have been beside the bench on the ground. The reported quantities of litter were always volume, without considering the weight or type of garbage. Volume as indicator was selected because it is closest to the visual impact litter has. Weight would strongly bias the measurement towards overestimating the impact of litter made from glass or metal. Volume might lead to overestimating larger over smaller items, which was desired, because large items are more visible, also from greater distance. The garbage was filled in bags to determine the volume—or directly measured, if larger volumes were encountered (e.g., shopping bags filled with garbage). Because volume depends strongly on the compression, the instruction was to keep the form of the garbage collected as much as possible (i.e., to compress as little as possible). Nevertheless, larger and harder pieces of garbage (e.g., bottles) might have been somewhat overestimated compared to smaller and softer variants (e.g., paper). After reporting the volume, the garbage was correctly disposed.

The number of data points was completely determined by the structure of the zones—limiting the maximum amount of possible measurement points—and the time available to investigate littering—limiting the number of days to measure litter. Data were gathered during the entire study period and only halted in case of particularly bad weather. Therefore, no a-priori power analyses were performed.

3.1.5 Data analyses

Within the preparative study, it was planned to investigate some basic-research questions. The pre-registered (<https://doi.org/10.17605/OSF.IO/52C3A>) hypotheses relate effects of the posters to changes in psychological constructs assessed with questionnaires. However, because in too many zones too few data could be collected by questionnaires, these analyses could not be performed. The presented research is purely explorative and omits questionnaire data.

In general, littering was low (82.9% of values were zero), however, on some days, at some measurement points, large amounts of litter were encountered (0.7% of the measurements have values >10 L, with up to 277 L). This distribution did not allow any traditional statistical approach and, thus, the data were analyzed differently. The effect of interest is the difference between the change of litter due to an intervention compared to the change of litter in the control condition (i.e., how much more litter was reduced in the intervention zone than in the control zone). A straightforward approach to test this with the encountered irregular distribution is to bootstrap this difference of changes. We bootstrapped the 90% confidence intervals to estimate the range of effects with $p < 0.05$ for a one-sided hypothesis of reducing the amount of litter. The analyses were done with R Project for Statistical Computing (RRID:SCR_001905). The data and scripts for these analyses are provided on <https://osf.io/s32qp/>.

We calculated the average of the measures during the intervention (short-term effect) or after the intervention (long-term effect) in the target zone and the structurally most similar control zones. The between-zone difference of the within-zone changes provides the value of the effect. For example, to test the effect of the intervention in Zone 3 in Phase 4, we bootstrapped the differences of the change of means from Phase 3 to Phase 4 (short-term) and Phase 3 to Phase 5 (long-term) in Zone 3 (intervention) and Zone 1 (control):

$$\begin{aligned} \text{Short Term Effect}_{43} &= \left(\begin{array}{l} \text{mean Volume Zone 3 Phase 4} \\ - \text{mean Volume Zone 3 Phase 3} \end{array} \right) \\ &\quad - \left(\begin{array}{l} \text{mean Volume Zone 1 Phase 4} \\ - \text{mean Volume Zone 1 Phase 3} \end{array} \right) \end{aligned}$$

$$\begin{aligned} \text{Long Term Effect}_{43} &= \left(\begin{array}{l} \text{mean Volume Zone 3 Phase 5} \\ - \text{mean Volume Zone 3 Phase 3} \end{array} \right) \\ &\quad - \left(\begin{array}{l} \text{mean Volume Zone 1 Phase 5} \\ - \text{mean Volume Zone 1 Phase 3} \end{array} \right) \end{aligned}$$

With this design, we controlled for confounding effects, for example, due to phases with generally more or less produced garbage in the park. By using the mean (instead of the sum) of measures per zone, we also control for possible effects due to the number of measurement points. Still, order effects cannot be ruled out. These cannot be controlled for, within the analysis, but were controlled qualitatively based on the resulting effects. An increase of the effects over time would indicate that previous interventions might be an important factor for later effects. A decrease of effects could indicate that the amount of littering was so much reduced by previous interventions that too little litter was present for later interventions to be able to show effects.

For testing whether enough litter was present before the interventions to identify an effect, we calculated the potential for

change, which expresses how much a perfect intervention could reduce litter. This potential is calculated by adding the change in the control zone to the amount of litter in the intervention zone before the intervention. Thus, the potential for change expresses the amount of litter in the intervention zone assuming a change equal to that of the control zone. For the above-mentioned example of long-term effect, the intervention potential would be:

$$\begin{aligned} \text{Long Term Intervention Potential}_{43} \\ &= \text{mean Volume Zone 3 Phase 3} \\ &+ \text{mean Volume Zone 1 Phase 4} \\ &- \text{mean Volume Zone 1 Phase 3} \end{aligned}$$

3.2 Results

Litter was measured on 119 out of 147 days, leading to 6,536 measurements. Of these, 82.9% had a value of 0.0 L, 14.3% had a value between 0 and 1 L, 1.1% had a value between 1 and 2.5 L, 1.0% had a value between 2.5 and 10 L, and 0.7% had a value of more than 10 L up to 277 L. So, in general, littering was low, and the total amount dominated by some rare high values. Table 2 compiles the average amounts of litter measured per measurement point in the different zones and phases, and Table 3 compiles the bootstrapped differences of changes.

Table 3 shows that, short-term (i.e., while the interventions were set up), none of the interventions reduced litter significantly. The only statistically significant effect is an *increase* in measured litter for the first NGdi intervention (estimated effect = 1.40, 95% CI = [0.37, 2.29]). However, long-term (i.e., comparing values of the control phase directly after the interventions to before the interventions), both information-based posters in Zones 2 and 6 (IE, estimated effects −1.47 and −0.12), the activation of the reciprocity norm in Zone 3 (NGr, estimated effect = −5.29), the affect-oriented poster in Zone 6 (AE, estimated effect = −0.18), and the structural measure in Zone 7 (estimated effect = −0.14) all reduced litter significantly.

Table 3 also shows that the potential for change, in some cases, was small or even negative (6 of 13 changes had a potential <0.05 L). For most non-significant long-term effects, the potential for change was 0.05 L or smaller. This lack of effects in some cases might be due to a lack of litter that the interventions could have reduced. Of the remaining two non-significant long-term effects with a potential for change >0.05 L, the combined structural and AE-IE intervention had

a marginal non-significant effect in the expected direction (estimated effect = −0.08). Only the intervention on disgust (NT) was clearly non-significant and even shows a tendency towards an increase in litter (estimated effect = 3.29).

The interventions with significant long-term effects reduced littering by 86–97% of the potential for change, while the marginally non-significant combined structural and AE-IE intervention reduced littering by 54%. Thus, except for the intervention on disgust and on injunctive and descriptive norms, all measures lead to considerable long-term effects. Due to the small potentials for change for both zones in which the intervention on injunctive and descriptive norms were applied, no conclusive results for the effect of this intervention on reducing littering can be derived.

Regarding order effects, Table 3 shows that in Zone 2 the first intervention had a significant effect and for all further intervention the potential for change was <0.05. In Zone 3, the first intervention had no significant effect, while the second intervention had a significant effect. Then, again, for the last intervention, the potential for change was <0.05 L. In Zone 6, the first intervention had a significant effect, but also the second intervention in Phase 4. For the third intervention, the potential for change was, again, < 0.05 L. Finally, in Zone 7, the first intervention had a significant effect, and the second a marginally non-significant effect. In Phase 6, the potential for change was <0.05 L. We conclude that an order effect exists with the first interventions having more chances to reach high effect strengths. Nevertheless, not all interventions in the first wave of interventions showed significant effects and some interventions in the second wave of interventions had significant effects. An increase of effects over time due to adding up of intervention effects was not observed, but the potential for change resulted in a powerful indicator for the interpretability of results. Note that, for all interventions except NG_{di}, the effects could be estimated due to a large-enough potential for change, at least once. For NG_{di}, a significant negative short-term effect (i.e., increase of litter) was found, indicating potential problems with this intervention.

4 Large-scale campaign

4.1 Introduction

The preparative investigation identified processes that could be targeted by campaigns to reduce littering. Most psychological studies stop at this point and conclude that the results can be used to

TABLE 2 Average liters of litter collected per measurement point in the different zones and phases.

	<i>n</i> of MP	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Total
<i>n</i> of MP		21	18	12	18	13	20	17	119
Zone 1	9	0.056	0.235	0.546	0.196	0.392	0.149	0.238	0.232
Zone 2	10	1.176	0.748	0.197	1.250	0.203	0.298	1.928	0.877
Zone 3	8	1.800	1.209	5.582	0.630	0.138	0.107	0.094	1.210
Zone 4	4	1.571	1.444	0.013	0.433	0.088	0.057	0.021	0.585
Zone 5	5	0.010	0.048	0.052	0.111	0.182	0.137	0.146	0.095
Zone 6	16	0.144	0.066	0.009	0.102	0.020	0.061	0.094	0.077
Zone 7	3	0.113	0.075	0.014	0.007	0.067	0.108	0.181	0.085
Total	55	0.649	0.483	0.946	0.421	0.153	0.134	0.455	0.451

n of MP indicates the number of measurement points per zone and phase, respectively.

TABLE 3 Bootstrapped differences of changes of measured litter (averages per measurement point) in liters.

Intervention	Phase	Zone		Short-term				Long-term			
		I	C	Pot.	Est.	LL	UL	Pot.	Est.	LL	UL
IE	2	2	1	1.36	−0.61	−1.95	1.02	1.67	−1.47	−2.58	−0.06
IE	4	6	5	0.07	0.03	−0.17	0.19	0.14	−0.12	−0.22	−0.02
NGdi	4	2	1	−0.15	<i>1.40</i>	<i>0.55</i>	<i>2.15</i>	0.04	0.16	−0.36	0.76
NGdi	6	4	5	0.04	0.01	−0.16	0.19	0.05	−0.03	−0.21	0.17
NGr	4	3	1	5.23	−4.60	−8.79	0.47	5.43	−5.29	−9.59	−0.61
NGr	6	6	5	−0.02	0.09	−0.06	0.23	−0.02	0.11	−0.05	0.27
AE	6	3	1	−0.11	0.21	−0.21	0.52	−0.02	0.11	−0.42	0.46
AE	2	6	5	0.18	−0.12	−0.26	0.05	0.19	−0.18	−0.30	−0.02
NT	6	2	1	−0.04	0.34	−0.09	0.71	0.05	1.88	−1.54	3.79
NT	2	3	1	1.98	−0.77	−3.06	1.46	2.29	3.29	−1.87	7.87
Structural	2	7	5	0.15	−0.08	−0.20	0.05	0.16	−0.14	−0.23	−0.04
Str. and AE-IE	4	7	5	0.07	−0.07	−0.16	0.05	0.14	−0.08	−0.18	0.02
AE-IE	6	7	5	0.02	0.09	−0.26	0.23	0.03	0.15	−0.03	0.31

Short-term, intervention phase–pre-intervention phase; long-term, post-intervention phase–pre-intervention phase; I, intervention zone; C, control zone; Pot., potential for change; Est., estimate; LL, lower limit; UL, upper limit of the 90% confidence intervals (bootstrapped with 1,000 replicates); The intervention abbreviations (e.g., IE) refer to the manipulations presented in Figure 3. Bold font highlights statistically significant effects with $p < 0.05$ one-sided, expecting a reduction. Italic font highlights statistically significant effects with $p < 0.05$ two-sided, in the case of an (unexpected) increase in litter.

design future interventions. This might give the false impression that it is a small step from having quantified effects to launching a behavior-change campaign. However, the development of a large-scale campaign is an enormous endeavor that goes far beyond upscaling preparative investigations. While not generalizable, we provide a brief description of how the large-scale campaign was designed based on the preparative study.

First, the problem a campaign shall mitigate needs to be revised based on the data gathered during the preparative study—which is much more than the data used in the quantitative analyses. Any piece of information, even anecdotal observations, can be helpful to improve the campaign design. In the present case, it was observed that the collected litter around the garbage bins was often torn into small pieces. This indicates that animals in the park rather than humans distributed this garbage. Also, it was observed that garbage was frequently placed in bags beside the garbage bins, sometimes because the garbage bins were full and sometimes, whilst the bins were empty. Together with the overall low level of littering in the park, the goal of the large-scale campaign was not so much to reduce littering, in general, but to reduce depositing garbage besides garbage bins.

While the preparative study focused on psychological measures, the campaign design also comprised structural components, particularly setting up additional garbage containers at locations that the preparative study identified as critical. Providing options to collect garbage fractions separately was proposed but rejected due to the high costs involved. Finally, a psychological measure was developed that prompted people not to deposit garbage beside the bins but to take it to the next container, if it did not fit in the bin.

Because the posters of the preparative study were designed to target one specific psychological dimension each and littering in general, the poster for the large-scale campaign was designed from scratch. Based on the result of the preparative study that particularly targeting instrumental and affective evaluations reduced littering, while targeting norms and tension states had rather unclear effects,

the poster was designed to inform in a funny way and to avoid any appeals to injunctive norms. The poster was designed to visualize the problem of animals distributing garbage deposited beside the bins, as well as the solution of depositing garbage in large containers. Text was only used to clarify the message and to provide humorous notes. Finally, additional information that supports correct garbage disposal was provided. In 2022, the campaign was ready to be launched.

4.2 Materials and methods

The poster used for the campaign is presented in Figure 5 and follows the design principle explained in the introduction. It reads: “We are curious! Dispose of your waste in the container when the bin is full. Thank you.” The message should have been clear already by the picture, but complementary information was provided by the title text and at the bottom, such as, the locations of the large waste containers and the hours when the garbage is collected. A QR-code linked to the webpage of the campaign with further information. The poster was designed with only two colors that represented the problem (orange) and solution (green). The rest of the poster was mostly white with some gray to contrast with the colorful background of the park.

The campaign’s budget only comprised funds for the intervention material. Nevertheless, we wanted an estimate of the campaign’s impact. Therefore, data gathering and analysis were designed to maximize the information obtainable and minimize the effort. Data gathering consisted of photos taken from selected garbage bins by the Operational Service team. This was done with the maintenance personnels’ smartphones, but still, taking off the work gloves, preparing the telephone, taking the pictures, and putting the work gloves back on consumed valuable time. Therefore, the number of garbage bins monitored and the period of data gathering had to be limited. We agreed on monitoring 11 garbage bins for 13 weeks. Two photos per bin were taken from orthogonal

directions before they were emptied, and the area was cleaned up, what usually happened twice a day (in the early morning and shortly after noon). The photos were analyzed by a student assistant, who estimated the volume of garbage beside the garbage bins based on systematic estimation guidelines and co-checked by one of the authors.

To get something like a control condition, around 5 garbage bins, no posters were placed. Besides these 5 'control' bins, 6 bins that had posters beside them were monitored. As baseline and post-intervention phases, the monitoring started 4 weeks before the campaign started and ended 3 weeks after the campaign ended. Therefore, in weeks 5 to 10 of the monitoring period, posters were installed. This data-gathering design allowed the data to be analyzed as in the 2019 preparative study presented above. To exclude periods with particularly bad weather and some days with unusual events (e.g., the SOLA relay race), for the pre-intervention period, only Days 15 to 26 (72 data points in the intervention and 60 in the control condition) were analyzed, and for the intervention period, Days 43 to 71 (174 data points in the intervention and 145 in the control condition) were analyzed. For the post-intervention period, Days 76 to 92 (102 data points in the intervention and 85 in the control condition) were considered in the analysis.

As mentioned, instead of area-wide picnic littering, the campaign focused on reducing garbage explicitly deposited beside the garbage bins. Because both kinds of littering can happen around the garbage bins, we used the amount to distinguish them, assuming that large volumes (e.g., bags with litter, pizza cartons) are the kind of litter we are interested in reducing. Therefore, the analyses were conducted with all the raw data first, and then with values between 0 and 40 L recoded to 0, while larger values remained raw measures. The cut-off value was set to 40 L, because data explorations showed the strongest effect for this value, although only 23 measures (3.6%) were larger than zero. So, when interpreting the results, it must be considered that the estimated effects depend on this context-specific cut-off value.

4.3 Results

With all the raw data considered in the analysis, like in the preparative study, no short-term effect was found (average difference of changes = 0.012 L, 90% CI = [−3.412, 3.458]). The long-term effect shows a non-significant tendency towards a reduction in littering (average difference of changes = −0.416 L, 90% CI = [−2.55, 2.145]). Again, most measures (88.2%) had values of 0, but sometimes also large values up to 702 L were reported. More than 25 L was measured in 3.3% of the cases.

When raw values up to 40 L were set to 0 (to exclude area-wide littering) a relevant long-term effect of −1.54 L (90% CI = [−3.09, 0.74], 80% CI = [−3.09, −0.04]) was identified. Identifying such a positive tendency is a promising result, considering the few data available and the challenges of investigations in applied settings.

5 Discussion

This paper presented a theoretical tool and methodological approach for designing and evaluating large-scale campaigns based on scientific evidence and methods. This approach was used to develop a

large-scale campaign in an urban park, and to estimate its impact on littering. We will start with discussing the results of the preparative study and the campaign evaluation, then discuss the methodological approach and theoretical tool, and finish the discussion with limitations and the practical implications of this paper.

5.1 Discussion of the results of the preparative study and the campaign evaluation

The preparative study was implemented as a quasi-experimental field study with experimental manipulations designed to have effects on one dimension of behavior determinants and not on others. The volume of litter was measured daily in three to four intervention and two to three control zones. By bootstrapping the differences of *changes* in the volume of litter in the intervention compared to the respective control zones, the effects of the interventions were estimated. This way, the importance of the different dimensions of behavior determinants in the specific location and the specific target population could be assessed without using surveys.

In the preparative study, no intervention showed significant effects in the expected direction when in place (i.e., short-term effects). However, several interventions reduced litter in the phase without intervention directly after the respective intervention phase compared to before this intervention. Such patterns were also found in other studies (e.g., Sibley and Liu, 2003). The reason for this might be that even behind the narrow specification of littering as picnic littering, many behaviors, such as preceding actions, like bringing along bags to collect garbage or not bringing single-use materials, are involved, that, finally, lead to solid waste being misplaced. Since people might only visit the park infrequently, even if the intervention was effective, it might take days or weeks to observe a change in the amount of litter, which might be observed only after interventions were already removed.

Significant long-term effects were found for the interventions targeting instrumental evaluation (information provision), norms and goals (activating reciprocity norms), affective evaluation (inducing positive emotions), and the structural feasibility measure (additional garbage container to dispose of cardboard separately). In most cases where no significant effect was observed, it could be attributed to not enough litter being in the respective zones to be reduced by the interventions. Here, an order effect was identified: In two out of three zones, after an intervention with significant effects, the potential for change was too small for the next intervention to be able to achieve any effects. Nevertheless, all interventions except the poster targeting descriptive and injunctive norms, could be tested with a large-enough potential for change – and not all resulted in significant effects. Particularly, the intervention on disgust did not reduce litter, despite having a large potential. Neither did the accompanying poster increase the structural measures' effect.

During the intervention phase, the only statistically significant effect was an *increase* of litter in a zone where injunctive and descriptive norms were targeted. This does not mean that these norms are not important determinants of litter avoidance. Particularly in questionnaire-based studies, norms mostly have a strong explicative power (e.g., Oduro-Appiah et al., 2024; Ojedokun et al., 2022; Farage et al., 2021). It even might be that the appeal to injunctive and

Wir sind neugierig!

Entsorgen Sie Ihren Abfall im Container, wenn der Eimer voll ist. Danke.



FIGURE 5
Poster of the follow-up campaign.

descriptive norms in our study has been too strong, and thus lead to reactance (Brehm, 1966) like those found for explicit commands in other studies (e.g., Reich and Robertson, 1979). Also, Gangl et al. (2022) found an increase of littering when using appeals to injunctive norms. However, an increase of litter was not found in the second zone where the same posters were set up, neither was it found when comparing the post- and pre-intervention phases, which might indicate that the effect was incidental. So, the effect of appealing to injunctive and descriptive norms remains inconclusive in our study.

A confounding effect due to applying different interventions simultaneously is improbable, due to the strong effects found for successful interventions, which showed between 86 to 97% of their theoretical maximal effect. If the intervention effects had diffused into

other zones, particularly the control zones, the effects would have been weaker or absent. Order effects regarding the reduction of the potential of change were already discussed. However, could later effects be partially caused by previous interventions? In Phase 4, two posters had significant effects. In Zone 3, NGr had a significant effect after the ineffective NT intervention. While improbable, it cannot be ruled out that the effect of the NGr intervention is only achieved by having previously a NT intervention. In Zone 6, IE was applied after AE, both with significant effects. However, IE also had a significant effect in Phase 2 (in Zone 2) and, thus, the effectiveness of this poster appears to be independent of previous interventions.

Besides creating the basis for designing the large-scale campaign, a small campaign was run during the preparative study in Zone 7. The

structural measure on feasibility by providing a second garbage container for collecting cardboard only, reduced littering in this zone significantly. An additional psychological intervention—a poster targeting the instrumental and affective evaluations by providing information in a funny way—appears to rather have reduced the effect of the structural measure. This leads to the conclusion that some littering is done intentionally to separate certain fractions of waste for recycling by the cleaning personnel. Therefore, providing the possibility to separately collect such waste fractions can reduce littering, indicating also an important role for feasibility and structural measures.

Based on the results of the preparative study, a large-scale campaign was developed and implemented. The posters that targeted a reduction of garbage deposited beside the garbage bins were designed mainly to provide information and induced positive emotions. While less data could be gathered than in the preparative study, the same analyses could be performed as for the latter. A reduction of larger amounts of garbage close to garbage bins was identified with $p < 0.10$ (one-sided, expecting a reduction). Considering the few data that could be gathered in this applied campaign, this result is promising and supports the theoretical and methodological approach presented.

5.2 Discussion of the approach in the light of differences between basic research and applied settings

The theoretical approach challenges the view of psychological constructs being specified by their operationalization as questionnaire items. It is not questioned that surveys are, in many situations, the most efficient form for gathering data from the target population and that these data can be valuable, also for designing campaigns. However, for the problem of designing behavior-change interventions, specifying constructs based on their expected role in changing behaviors is preferable. The proposed six dimensions are an assumption based on evidence found in literature and campaigning experiences but cannot be tested like a model or hypotheses. Rather, the proposed concept must prove that it is functional for designing successful campaigns.

It is open to discussion whether more, less, or different dimensions might lead to better campaign designs, but some rules the proposed dimensions are based on are general: Interventions targeting different dimensions should follow different design principles and, sufficiently often, not be applied together because of conflicting effects of the different dimensions. In turn, interventions targeting the same dimension should follow similar design principles and vary mainly in the content (e.g., whether an argument is about costs in money or in time). Further, the number of dimensions should not be too large and, maybe most importantly, for all dimensions it should be clear what is not included but part of other dimensions. The preparative study allows discussing these general points more specifically. A good example is the norms-and-goals dimension. Interventions on three different norms were applied, with two norms covered on a single poster. Why are these all placed on a single dimension? All three interventions refer to a socially desired behavior, without conveying any reasons of why the respective behavior would be desirable. While the effectiveness of different references to norms can vary, we still

assume that similar psychological processes are triggered. It might make a difference, whether norms are conveyed by reference to others' behavior or others' opinions. However, knowing about many people performing a behavior might strongly affect what a person thinks about the opinions of others, and the other way around. Therefore, all these interventions are considered targeting the same dimension.

For discussing the separation of dimensions, the difference between affective evaluation and needs and tension states is a good candidate. Both dimensions refer to affective states or emotions and, thus, combining them, as is done in most behavior models, might be obvious. However, interventions targeting these dimensions are very different. While affective-evaluation interventions mainly associate affective states with certain behaviors, interventions targeting cognitive tension states mostly provide information and arguments. These information and arguments target emotions, in contrast to information and arguments targeting costs and benefits for interventions on the instrumental evaluation dimension, or, for example, normative aspects for the norms-and-goals dimension. The striking difference in how these two dimensions are addressed by interventions requires distinguishing affective evaluation and needs and tension states. It is also important to note that, while needs and tension states affect behavior even with close to no cognitive effort involved, the creation and change of them might require considerable cognitive resources.

For data gathering, we proposed a quasi-experimental approach with experimental manipulations that target a single dimension of behavior determinants and affect as little as possible other dimensions. By measuring changes in the consequences of the behavior, such as the amount of litter, the relevance of the different dimensions for changing the behavior can be estimated. This approach omits surveys and behavior observations, but still allows conclusions about psychological processes involved. Nevertheless, it comes with its own challenges. The number of experimental conditions is limited by the specific setting and, due to the limited controllability, certain confounding or biasing effects cannot be ruled out. In the preparative investigation, we found no evidence for confounding effects due to applying several interventions in parallel, but order effects were identified, which made the estimation of effects for some later implemented interventions impossible. Such field investigation might not come close to laboratory experiments, but the advantage of measuring effects *in-situ* with the actual target population compensates for this.

A larger issue with the proposed approach might be seen in the question of validity, and how it can be known whether the posters actually addressed the theoretical dimensions. This is, however, a problem with any measurement. It remains also unknown whether a scale in a questionnaire assesses the construct it is meant to assess. Arguments to defend such instruments are based on expert opinions and conventions. Therefore, the same justification is used for the experimental manipulations used in the preparative study. If there is no reason to assume that these posters had effects on other dimensions, the experimental manipulations are judged valid. In fact, the validity problem is far less problematic with the proposed approach than with questionnaire-based measurements, because the process of generating the conclusions for the campaign are the same as the processes intended to trigger by the campaign. If a poster with a specific design principle shows an effect in the preparative study

and in the campaign the same design principle is used, the campaign could be successful even if the manipulation influenced a different dimension than assumed. In the case of questionnaire-based measures, such error could be fatal. For example, if attitudes are identified as critical, but the measure is mainly influenced by normative considerations, a campaign targeting attitudes would fail. Of course, both data-gathering approaches could be combined, and the data correlated—what we planned to do in the preparative study, but the surveys failed to deliver useful data. However, if the correlation is low, it would remain unclear, whether the problem lies in the experimental manipulation, the questionnaire measure, or different issues.

Finally, it is important to highlight the differences between the preparative study, which is considerably closer to common field research, to the large-scale campaign. First, the final intervention is very different from the experimental manipulations used in the preparative study. As already mentioned, the latter was not designed to maximize behavior change or find the intervention to maximize such impact. The study targeted an understanding of psychological processes relevant for a behavior-change campaign. The large-scale campaign was then designed based on all the information compiled during the preparative study—not only the effect estimates, but also, for example, rather anecdotal evidence on the litter collected. Another important difference is the limited possibilities for gathering and analyzing data within large-scale campaigns. Surveys are often difficult and even simple measurements, such as taking photos, must be limited to a minimum. Nevertheless, the proposed approach for data gathering and analysis allowed a rough estimation of the campaign effect.

5.3 Strengths and limitations

While this study contributes to the evidence on possible determinants of litter avoidance behavior and effects of large-scale litter-reduction campaigns, its contributions lay mostly in the applied sector. The proposed theoretical and methodological approach proved to be feasible for designing and evaluating large-scale campaigns. We demonstrated how behavior should be specified from a psychological perspective and we translated questionnaire-oriented construct specifications into intervention-oriented dimensions. This theoretical concept allows investigating behavior determinants without depending on surveys and supports the development of behavior-change campaigns. However, even when working with this tool, the step from a preparative investigation to a large-scale campaign is huge. We described some considerations for such a step, but these might vary from campaign to campaign. Therefore, the main goal of demonstrating the feasibility of the proposed approach for evidence-based design of campaigns was achieved.

Nevertheless, some limitations need to be discussed. Particularly challenging was the distribution of littering. For most days and measurement points, no or very little litter was measured, but some measurements revealed enormous numbers. While the lack of a constant rate of baseline littering makes the statistical detection of a reduction of littering due to interventions difficult, such data distributions might be frequent, in the case of littering. Also, other studies encountered frequent low amounts of littering (e.g., Bator

et al., 2011; Gangl et al., 2022) and subjective estimates of littering might be overestimated due to litter being highly salient, while the absence of litter is hardly noticed. A pile of garbage 1 day might lead to the conclusion that an entire park has a littering problem, despite having no litter on most days and at most locations. Therefore, analysis methods are required that can deal with such data distributions—and too smooth data distributions might even be questioned.

Further limitations come from the already several times mentioned limited controllability of studies in field settings. It cannot be ruled out that the effect of the campaign posters might be moderated by the differences of the zones and the populations visiting them. In turn, it is possible that the manipulations had effects in zones other than those they were used in. Because clear differences between the zones could be identified and the effects are rather strong, the latter problem might not have been present in this study.

Finally, for the preparative study, further investigations were planned and pre-registered. These investigations were based on questionnaire data, which could not be gathered in an adequate form. Therefore, the pre-registered analyses could not be realized.

5.4 Practical implications

For practice, the most important contribution is the introduced approach to identify the critical determinants for changing a behavior in a specific setting. Whenever several comparable but isolated zones can be specified, the proposed approach can be used to gather the information, based on which behavior change campaigns can be designed for a specific location and target group. While the posters (or other types of manipulations) need to be adapted to the specific situation, conceptually, the study could be applied to any place and other behaviors to identify critical determinants. However, the proposed approach requires a different theoretical basis than common basic-research studies. A specification of a relatively small number of classes or dimensions of behavior determinants is required, which are clearly distinguishable regarding how they are manipulated. Testing whether a certain construct, such as attitudes, determine behaviors or behavior changes, is very different from exploring what determines the change of a behavior, for which a campaign is developed.

With respect to littering, the results indicate three promising determinants on which campaigns can focus to reduce littering. First, the effect of structural measures was reconfirmed. Further, providing information on the problem and inducing more positive emotions related to littering-reducing behaviors appear to help reduce littering. Norms appear to be important factors for littering reduction, but direct norm appeals might not have the desired results. In our study, activating injunctive and descriptive norms led to an increase of littering, maybe due to reactance. So, less explicit measures to activate norms, such as reducing litter to convey the descriptive norm or the use of models for injunctive norms, might be more fruitful (but also much more expensive). Also appealing to reciprocity norms led to desired effects. In the investigated setting, the posters that targeted the tension state of disgust did not have any effect. This might be due to visitors in this park already wrapping garbage before it becomes disgusting, thus, this measure might work in other settings. However, it is also possible that disgust is not a relevant factor for reducing littering.

More generally, we advocate for theoretical and methodological approaches that are better suited to deal with problems of applied settings. While basic research continues to be the foundation of applications, the requirements and challenges of applied settings are different from the ones of basic research. In turn, it would also be important to consider evidence collected in applied settings in theory building. While confounding effects cannot be fully ruled out and data quality is sometimes low, repeatedly successfully designed campaigns would be a strong indicator that psychological processes were well identified and play an important role in changing the targeted behavior.

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: OSF <https://osf.io/s32qp/>.

Ethics statement

The studies involving humans were approved by Ethics Committee of the Faculty of Arts and Social Sciences of the University of Zurich. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RT: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft. NM: Data curation, Formal analysis, Investigation, Supervision, Writing – review & editing. BD: Conceptualization, Data curation, Funding acquisition, Project administration, Resources, Writing – review & editing.

References

- Ai, P., and Rosenthal, S. (2024). The model of norm-regulated responsibility for proenvironmental behavior in the context of littering prevention. *Sci. Rep.* 14, 9289–9212. doi: 10.1038/s41598-024-60047-0
- Ajzen, I. (1991). The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50, 179–211. doi: 10.1016/0749-5978(91)90020-T
- Aunger, R., and Curtis, V. (2013). The anatomy of motivation: an evolutionary-ecological approach. *Biol. Theory* 8, 49–63. doi: 10.1007/s13752-013-0101-7
- Bamberg, S. (2013). Changing environmentally harmful behaviors: a stage model of self-regulated behavioral change. *J. Environ. Psychol.* 34, 151–159. doi: 10.1016/j.jenvp.2013.01.002
- Bator, R. J., Bryan, A. D., and Wesley Schultz, P. (2011). Who gives a hoot?: intercept surveys of litterers and disposers. *Environ. Behav.* 43, 295–315. doi: 10.1177/0013916509356884
- Berger, T., Staub, A., and Heeb, J. (2008). Handbuch littering. Eine Praxishilfe zur Entwicklung von Massnahmen gegen littering [handbook littering. A practical aid for the development of measures against littering]. Aarau, Switzerland: seecon GmbH. Available at: https://www.littering-toolbox.ch/fileadmin/Media/Downloads/D4_handbuch_littering_version_2008.pdf (Accessed October 06, 2024).
- Brandstätter, V., and Bernecker, K. (2022). Persistence and disengagement in personal goal pursuit. *Ann. Rev. Psychol.* 73, 271–299. doi: 10.1146/annurev-psych-020821-110710
- Breckler, S. J., and Wiggins, E. C. (1989). Affect versus evaluation in the structure of attitudes. *J. Exp. Soc. Psychol.* 25, 253–271. doi: 10.1016/0022-1031(89)90022-X
- Brehm, J. W. (1966). A theory of psychological reactance. New York: Academic Press.
- Burgess, R. L., Clark, R. N., and Hendee, J. C. (1971). An experimental analysis of anti-litter procedures. *J. Appl. Behav. Anal.* 4, 71–75. doi: 10.1901/jaba.1971.4-71
- Chaudhary, A. H., Polonsky, M. J., and McClaren, N. (2021). Littering behaviour: a systematic review. *Int. J. Consum. Stud.* 45, 478–510. doi: 10.1111/ijcs.12638
- Cialdini, R. B., Reno, R. R., and Kallgren, C. A. (1990). A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places. *J. Pers. Soc. Psychol.* 58, 1015–1026. doi: 10.1037/0022-3514.58.6.1015
- Cone, J. D., and Hayes, S. C. (1980). Environmental problems: Behavioral solutions. Monterey, CA: Brooks/Cole.
- Curtis, V., Aunger, R., and Rabie, T. (2004). Evidence that disgust evolved to protect from risk of disease. *Proceed. R. Soc. London* 271(suppl_4), S131–S133. Available at: <https://royalsocietypublishing.org/doi/10.1098/rsbl.2003.0144>
- Degenhardt, B., and Buchecker, M. (2012). Exploring everyday self-regulation in nearby nature: determinants, patterns, and a framework of nearby outdoor recreation behavior. *Leis. Sci.* 34, 450–469. doi: 10.1080/01490400.2012.714706
- Dittmar, H. (1992). The social psychology of material possessions: To have is to be. New York, NY: Hemel Hempstead, Harvester Wheatsheaf and St Martin's Press.
- Farage, L., Uhl-Haedicke, I., and Hansen, N. (2021). Problem awareness does not predict littering: a field study on littering in the Gambia. *J. Environ. Psychol.* 77:101686. doi: 10.1016/j.jenvp.2021.101686

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research was financially supported by Portfolio and Asset Management of the University of Zurich for designing and producing the intervention materials. The open access publication fees were funded by the Publication Fund for Humanities and Social Sciences of the University Library Zurich and the Chair of Social Psychology of the University of Zurich.

Acknowledgments

We thank the Operating Services of the Campus Irchel of the University of Zurich, particularly the teams Services and Special Cleaning, for their practical help in implementing the field studies. Mischa Moraz constructed the racks for setting up the posters of the field experiment. Further thanks go to the interns Lucas Baeriswyl, Mirjam Preiswerk, and Veronica Tommassini for gathering the data in the field experiment.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- Gangl, K., Walter, A., and Van Lange, P. A. M. (2022). Implicit reminders of reputation and nature reduce littering more than explicit information on injunctive norms and monetary costs. *J. Environ. Psychol.* 84:101914. doi: 10.1016/j.jenvp.2022.101914
- Gatersleben, B., and Steg, L. (2013). Affective and symbolic aspects of environmental behaviour. In L. Steg, Berg A. E. van den and Grootj. I. M. de (Eds.), *Environmental psychology: an introduction* (pp. 165–174). Chichester: BPS Blackwell.
- Geller, E. S. (1980). “Applications of behavioral analysis for litter control” in *Behavioral community psychology: progress and prospects*. eds. D. Glenwick and L. Jason (New York, NY: Praeger), 254–283.
- Geller, E. S., Winett, R. A., and Everett, P. B. (1982). *Preserving the environment: new strategies for behavior change*. Elmsford, NY: Pergamon.
- Gollwitzer, P. M., and Sheeran, P. (2006). Implementation intentions and goal achievement: a meta-analysis of effects and processes. *Adv. Exp. Soc. Psychol.* 38, 69–119. doi: 10.1016/S0065-2601(06)38002-1
- Hagger, M. S., Moyers, S., McAnally, K., and McKinley, L. E. (2020). Known knowns and known unknowns on behavior change interventions and mechanisms of action. *Health Psychol. Rev.* 14, 199–212. doi: 10.1080/17437199.2020.1719184
- Hansmann, R., and Scholz, R. W. (2003). A two-step informational strategy for reducing littering behavior in a cinema. *Environ. Behav.* 35, 752–762. doi: 10.1177/0013916503254755
- Hansmann, R., and Steimer, N. (2016). A field experiment on behavioural effects of humorous, environmentally oriented and authoritarian posters against littering. *Environ. Res. Eng. Manag.* 72, 35–44.
- Hansmann, R., and Steimer, N. (2017). Subjective reasons for littering: a self-serving attribution bias as justification process in an environmental behaviour model. *Environ. Res. Eng. Manag.* 73, 8–19. doi: 10.5755/j01.erem.73.1.18521
- Hossain, I., Nekmahmud, M., and Fekete-Farkas, M. (2022). How do environmental knowledge, eco-label knowledge, and green trust impact consumers' pro-environmental behaviour for energy-efficient household appliances? *Sustain. For.* 14:6513. doi: 10.3390/su14116513
- Johnson, R. C., Danko, G. P., Darvill, D. J., Bochner, S., Bowers, J. K., Huang, Y.-H., et al. (1989). Cross-cultural assessment of altruism and its correlates. *Personal. Individ. Differ.* 10, 855–868. doi: 10.1016/0191-8869(89)90021-4
- Keizer, K., Lindenberg, S., and Steg, L. (2008). The spreading of disorder. *Science* 322, 1681–1685. doi: 10.1126/science.1161405
- Klößner, C. A., and Blöbaum, A. (2010). A comprehensive action determination model: toward a broader understanding of ecological behaviour using the example of travel mode choice. *J. Environ. Psychol.* 30, 574–586. doi: 10.1016/j.jenvp.2010.03.001
- Liu, P., Tengb, M., and Han, C. (2020). How does environmental knowledge translate into pro-environmental behaviors?: the mediating role of environmental attitudes and behavioral intentions. *Sci. Total Environ.* 728:138126. doi: 10.1016/j.scitotenv.2020.138126
- McDaniel, M. A., and Einstein, G. O. (2007). *Prospective memory: An overview and synthesis of an emerging field*. Thousand Oaks, CA: Sage doi: 10.4135/9781452225913.
- Michie, S., Van Stralen, M. M., and West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement. Sci.* 6:42. doi: 10.1186/1748-5908-6-42
- Mori, Y., Nakamata, T., Kuwayama, R., Yuki, S., and Ohnuma, S. (2024). Developing the littering behavior model focusing on implementation intention: a challenge to anti-environmental behavior. *J. Material Cycles Waste Manag.* 26, 776–791. doi: 10.1007/s10163-024-01909-7.
- Oduro-Appiah, K., Afful, A., and Osei-Tutu, H. (2024). Using an extended model of the reasoned action approach to explore individual behavioral intentions regarding litter and plastic pollution prevention in a developing country. *Front. Psychol.* 14:1274765. doi: 10.3389/fpsyg.2023.1274765
- Ojedokun, O., Henschel, N., Arant, R., and Boehnke, K. (2022). Applying the theory of planned behaviour to littering prevention behaviour in a developing country (Nigeria). *Waste Manag.* 142, 19–28. doi: 10.1016/j.wasman.2022.02.006
- Pandey, J. (1990). “The environment, culture, and behavior” in *Applied cross-cultural psychology*. ed. R. Brislin (Thousand Oaks, CA: SAGE), 254–277.
- Rau, H., Nicolai, S., and Stoll-Kleemann, S. (2022). A systematic review to assess the evidence-based effectiveness, content, and success factors of behavior change interventions for enhancing pro-environmental behavior in individuals. *Front. Psychol.* 13:901927. doi: 10.3389/fpsyg.2022.901927
- Reich, J. W., and Robertson, J. L. (1979). Reactance and norm appeal in anti-littering messages. *J. Appl. Soc. Psychol.* 9, 91–101. doi: 10.1111/j.1559-1816.1979.tb00796.x
- Schultz, P. W., Bator, R. J., Large, L. B., Bruni, C. M., and Tabanico, J. J. (2013). Littering in context. *Environ. Behav.* 45, 35–59. doi: 10.1177/0013916511412179
- Schwartz, S. H. (1977). “Normative influences on altruism” in *Advances in experimental social psychology* volume 10. ed. L. Berkowitz, vol. 10 (New York: Elsevier), 221–279.
- Schwarzer, R. (2008). Modeling health behavior change: how to predict and modify the adoption and maintenance of health behaviors. *Appl. Psychol.* 57, 1–29. doi: 10.1111/j.1464-0597.2007.00325.x
- Sibley, C. G., and Liu, J. H. (2003). Differentiating active and passive littering. *Environ. Behav.* 35, 415–433. doi: 10.1177/0013916503035003006
- Skogan, W. (1990). *Decline and disorder: Crime and the spiral of decay in American neighborhoods*. New York, NY: Free Press.
- Tobias, R. (2009). Changing behavior by memory aids: a social psychological model of prospective memory and habit development tested with dynamic field data. *Psychol. Rev.* 116, 408–438. doi: 10.1037/a0015512
- Van Doesum, N. J., van der Wal, A. J., Boomsma, C., and Staats, H. (2021). Aesthetics and logistics in urban parks; can moving waste receptacles to park exits decrease littering? *J. Environ. Psychol.* 101669:77.
- Weaver, R. (2015). Littering in context(s): using a quasi-natural experiment to explore geographic influences on antisocial behavior. *Appl. Geogr.* 57, 142–153. doi: 10.1016/j.apgeog.2015.01.001
- Wicklund, R. A., and Gollwitzer, P. M. (1981). Symbolic self-completion, attempted influence, and self-deprecation. *Basic Appl. Soc. Psychol.* 2, 89–114. doi: 10.1207/s15324834basps0202_2



OPEN ACCESS

EDITED BY

Giuseppe Carrus,
Roma Tre University, Italy

REVIEWED BY

Glenda Garza-Teran,
University of Sonora, Mexico
Nahyang Byun,
Chungbuk National University, Republic of
Korea

*CORRESPONDENCE

Pedro Schimmelpfeng
✉ pedro.schimm@gmail.com

RECEIVED 05 April 2024

ACCEPTED 06 September 2024

PUBLISHED 30 October 2024

CITATION

Schimmelpfeng P, Lapa LG Jr and
Lyra Pato CM (2024) Psychological barriers in
children: an exploratory study on Dengue
transmission using an adapted DIPB scale.
Front. Psychol. 15:1412856.
doi: 10.3389/fpsyg.2024.1412856

COPYRIGHT

© 2024 Schimmelpfeng, Lapa and Lyra Pato.
This is an open-access article distributed
under the terms of the [Creative Commons
Attribution License \(CC BY\)](#). The use,
distribution or reproduction in other forums is
permitted, provided the original author(s) and
the copyright owner(s) are credited and that
the original publication in this journal is cited,
in accordance with accepted academic
practice. No use, distribution or reproduction
is permitted which does not comply with
these terms.

Psychological barriers in children: an exploratory study on Dengue transmission using an adapted DIPB scale

Pedro Schimmelpfeng*, Luiz Gonzaga Lapa Jr. and
Claudia Marcia Lyra Pato

School of Education, University of Brasília, Brasília, Brazil

Dengue is an arboviral infection found in tropical and subtropical regions transmitted by hematophagous mosquitoes from the genus *Aedes* spp. and responsible for millions of cases every year. Public campaigns and educational curriculum are designed to educate people, including children. However, what has been reported is that many decide not to follow these guidelines, even though they allegedly know what has to be done. To understand this phenomenon, this study aims to identify psychological barriers behind the adoption of pro-environmental behaviors that seek to reduce *Aedes aegypti*'s population. For that, middle school students participated on two studies responsible for (1) adapting the Dragons of Inaction Psychological Barrier (DIPB) scale to the target group ($n = 150$) and then (2) testing it on a larger group ($n = 449$). In the exploratory factor analysis, Bartlett correlation ($p < 0.001$), Cronbach's alpha (0.83), and KMO analysis (overall MSA = 0.84) showed that data was suited for factor analysis. Five factors were retained by Kaiser Criterion and scree test (i.e., Conflicting goals and unnecessary changes— α 0.76, Interpersonal relations— α 0.72, Conflicting goals and lacking knowledge— α 0.58, Tokenism— α 0.73, and Tokenism toward the government— α 0.66). After that, the scale was tested across 11 different schools, where students also answered a questionnaire about the mosquito. Results suggested that the factors Conflicting goals and lacking knowledge and Tokenism toward the government presented a higher level of agreement for all students (means: 2.6 and 2.12 out of five, respectively). Those who scored higher in the mosquito's questionnaire had factors Conflicting goals and unnecessary change and Interpersonal relations inhibited when compared to others ($p < 0.05$). These results suggests that future educational campaigns should build different actions that focuses on addressing both internal and external factors, creating a mosaic of projects, with different goals, each aiming different environmental challenges.

KEYWORDS

pro-environmental behavior, environmental education, dragons of inaction, Dengue fever, *Aedes aegypti*, psychological barriers

Introduction

Dengue is an arboviral infection found in tropical and subtropical regions, causing 400 million cases and 22,000 deaths worldwide every year (Hosseini et al., 2018; Roy and Bhattacharjee, 2021). In Brazil, *A. aegypti* and Dengue reemerged over 40 years ago (Teixeira et al., 2009), and while in 2022 1.393.684 probable cases were identified, more than 5 million

cases were reported for the first semester of 2024 already (Brazil, 2023, 2024).

Arboviruses are those transmitted by hematophagous arthropods and, in this case, by mosquitoes from the genus *Aedes* spp., where *Aedes aegypti* and *Aedes albopictus* are the most common ones (Kraemer et al., 2015). The mosquito's female feeds on the blood from its host to mature its eggs, which are later going to be deposited on stagnant water. It is during the feeding moment that the insect injects its saliva, which may contain the Dengue virus and others (i.e., Chikungunya, Zika and Yellow fever viruses) (Junior et al., 2015; Vu et al., 2017).

In nature, these insects usually use water that accumulates in some plant parts, like in bromeliads, for example. However, in urban environments, they find a larger number of options, like plates of plants, empty bottles, open water tanks, poorly discarded tires and others. These objects can easily accumulate water from the rain and become adequate spots for oviposition.

To reduce the mosquitoes' population, a combination of actions from the government and general public are necessary (i.e., environmental interventions) (Zara et al., 2016). From the population's perspective, to avoid any stagnant water in their houses and appropriate trash disposal are the most effective interventions. These reduce entomological indicators, involve few resources, and are easy to implement (Tortosa-La Osa et al., 2022).

The set of behaviors necessary for these interventions are called Pro-Environmental Behaviors (PEB's) (Iglesias et al., 2014; Karp, 1996; Lange and Dewitte, 2019). To achieve this set, multiple variable are taken into consideration, split into personal and context levels of approach (Corral-Verdugo and Pinheiro, 1999; Schultz and Kaiser, 2012), internal and external factors (Kollmuss and Agyeman, 2010) and cultural aspects of societies (Tam and Chan, 2017).

Nevertheless, when considering that PEB's cannot be imposed, what can be achieved is the establishment of a positive attitude toward a specific behavior, that is built alongside a strong system of values and beliefs (Best and Mayerl, 2013; Corraliza and Berenguer, 2000; Pato and Delabrida, 2019; Pato and Tamayo, 2006). In order to better understand this phenomenon, many articles have discussed it in recent years using a wide variety of groups and scenarios, like celebrities endorsement on the use of single-use plastics (Ho et al., 2022), how policy makers can encourage PEB amongst their target audiences (Lucas et al., 2008), meat consumption (Graves and Roelich, 2021), and others (Grilli and Curtis, 2021; Yuriev et al., 2018).

However, despite some positive results, what is seen in recent literature is a gap between presenting a positive attitude toward PEBs and actually manifesting them (Gaspar, 2013; Kollmuss and Agyeman, 2010; Quimby and Angelique, 2011). These psychological barriers are explained by a number of factors, which have been named Dragons of Inaction (Gifford, 2011).

Most recently, a study tried to develop a scale to assess factors involved in the lack of action toward various environmental problems (Lacroix et al., 2019) [i.e., (1) Change unnecessary, (2) Conflicting goals and aspirations, (3) Interpersonal relations, (4) Lacking knowledge, and (5) Tokenism]. This scale, called the Dragons of Inaction Psychological Barriers' scale (DIPB scale) has been validated and tested by undergrad students in Canada (Lacroix et al., 2019), United States (Mouchrek et al., 2022) and Colombia (Gutiérrez et al., 2022), but it has not been validated in Brazilian territory or a younger

group of people. Factors within a scale are variables that are being tested for a specific barrier.

Regarding *A. aegypti*, the population is usually instigated by various educational programs accessed over the television and activities in schools, parks, and public spaces. Not only that, but sanitary agents also visit residences to check for possible sites of oviposition and to answer questions by the public. Although educational campaigns have previously shown a positive correlation between knowledge and preventive practices (Brusich et al., 2015; Yasmeen et al., 2015), there is still a group of people who choose not to take part on it (Caregnato et al., 2008; Chiaravalloti Neto, 1997; Chiaravalloti Neto et al., 1998; Chiaravalloti et al., 2002; Claro et al., 2004). At the same time, a more recent review recognizes that educational campaigns are essential to reduce breeding sites and interrupt disease transmission, but questions the quality of evidence, considering a multi modal approach (Bouazid et al., 2016). To propose new insights on how educational campaigns can be more effective to prevent mosquitoes' proliferation, this study aims to identify possible psychological barriers behind the adoption of pro-environmental behaviors expected to reduce *Aedes aegypti*'s population.

Materials and methods

This is an exploratory study where two questionnaires were used to create enough data for a quantitative analysis. This article is divided than into two studies, one for validating the Dragons of Inaction Psychological Barriers scale and the second for verifying possible barriers and assimilation of concepts by students from different schools.

Data collection and participants

For both studies, 11 public schools from the city of Volta Redonda, Brazil, all urban, were visited. Then, seventh grade students (age's mean 12.52 years old, SD=0.866) were selected to answer the questionnaires during the year of 2023. The city is located in the inner part of Rio de Janeiro's state, southeast of the country, and many educational campaigns have been made over the last years to educate its population on the expected PEB's to control the mosquito. These campaigns are mostly run through the radio and television, with specific educational actions also happening in city events, many targeted to children, and by public environmental agents that visit houses and other facilities to check for contaminated spots.

School's infrastructure varied depending on the city's regions, but a correlation between it and dengue's knowledge was not expected, considering that the majority of educational campaigns on this topic happens outside the school environment. Nevertheless, it is part of the 7th grade Brazilian science curriculum to discuss health indicators in a community, considering access to basic sanitation and common illness, such as Dengue fever. Because of these aspects, it is expected that children around that age and grade already have the knowledge expected to inhibit mosquitoes' proliferation.

Thus, after the initial contact with each school's principal, all schools were visited to explain what the research was about and invite students to participate. They were handed a form to be sent to their parents, explaining what the questionnaires were about,

research’s relevance, and contact information. Only students that turned in those documents, signed by one of their parents or legal caretakers, and agreed to participate in this research could answer the questionnaires on the following meeting. This study was approved by the human research ethics committee of the University of Brasilia.

On the agreed day, groups of 10 students were asked to come to the school’s library, where the questionnaires were handed, and instructions were given. After finishing answering it, they were sent back to class. The whole process for each group lasted 30 min approximately.

On the first study, 150 students (81 male and 69 female) were selected to answer the 22-items DIPB scale. These results were used for an Exploratory factor analysis (EFA), and, after making the required adjustments, the DIPB scale and Dengue’s questionnaire were applied to a new set of students following the same criteria ($n=449$, 213 males and 236 females) (Study 2). To present the results, items were later translated back to the English language again.

Dragons of inaction psychological barriers scale’s adaptation

Initially, the DIPB scale developed by Lacroix et al. (2019) had to be adapted to the Brazilian perspective. For that, first, three different English teachers translated each of the 22 items from the original scale. Secondly, items were adapted to accommodate to the literacy expected from kids at this age group (12–13 years old). To specify the relatedness to each of the items, a Likert scale-using emojis was used, based on a five point system (Bouranta et al., 2009; Lapa, 2019; Preston and Colman, 2000).

Dengue’s questionnaire

This questionnaire contained four questions, where each covered one of the major skills expected by the population to prevent mosquito’s reproduction and proliferation. They are: (Item 01) to recognize the different stages of the insect’s life cycle (egg, larvae, pupae, and adult), (Item 02) to associate its different stages to environmental factors (i.e., stagnant water), (Item 03) to recognize different diseases transmitted by the mosquito, and (Item 04) to identify the main prophylactic measures to reduce mosquito’s population.

On item 01, students would have to number the correct sequence that represents the order of stages for the insect’s life cycle (i.e., egg, larvae, pupae, and adult). On items 02, 03, and 04, students would be presented nine different options, where some of them were correct while others were wrong, having to identify, by marking an “X,” the correct ones.

For items 02, 03, and 04, in order to identify false positive results (i.e., students randomly guessing multiple items), options within the items that were marked incorrectly nullified a correct marking. The lowest score for each of those items would be zero, and students that scored maximum points did that by selecting only correct options.

In the end, each student would be graded from 0 to a 100 (i.e., 25 points from each question) based on the answers given. The set of results would then be divided into quartiles for data comparison with the DIPB scale.

Results

Study 1—Exploratory Factor Analysis

Principal axis factor analysis with oblimin rotation was used to extract factors. Bartlett correlation test ($p < 0.001$) and KMO analysis (overall MSA = 0.84; meritorious) showed that data was suited for factor analysis and α -Cronbach was 0.85. Items that showed low communalities (lower than 0.30) and/or were loaded in more than one factor were eliminated. The Kaiser Criterion (i.e., eigenvalue >1) and scree test suggested retaining five factors, explaining 62.66% of the variation. The results for the EFA proposed the removal of five items and reorganized the five factors (Table 1). From the remaining items, two of them (items 1 and 17) had low communalities but were retained due to its loadings within their correspondent factors.

The new factor distribution rearranged the 17 items into five different factors, where factor 01 contained five items and other factors three items (Table 2; Figure 1). Names of each factor were altered to accommodate the proposed changes.

Study 2—Dengue’s questionnaire test results

In total, the mean score was 68.95 and 70.8 median. Minimum score was 25 ($n=1$) while maximum score was 100 ($n=10$). Scores were grouped within quartiles, where first quartile was 58.3 ($n=109$), second quartile was 70.8 ($n=121$), third quartile was 79.10 ($n=128$), and fourth quartile ($n=91$) (Figure 2).

TABLE 1 Exploratory factor analysis—standard matrix.

Item	Factors				
	1	2	3	4	5
7	0.684				
10	0.620				
8	0.581				
2	0.541				
1	0.454				
14		0.778			
11		0.590			
13		0.546			
23			−0.872		
24			−0.561		
18			−0.397		
9				0.646	
17				0.511	
15				0.439	
20					−884
21					−0.650
19					−0.391

Extraction method: principal axis factor analysis. Rotation method: Oblimin and Kaiser normalization. Converged rotation after 11 iterations.

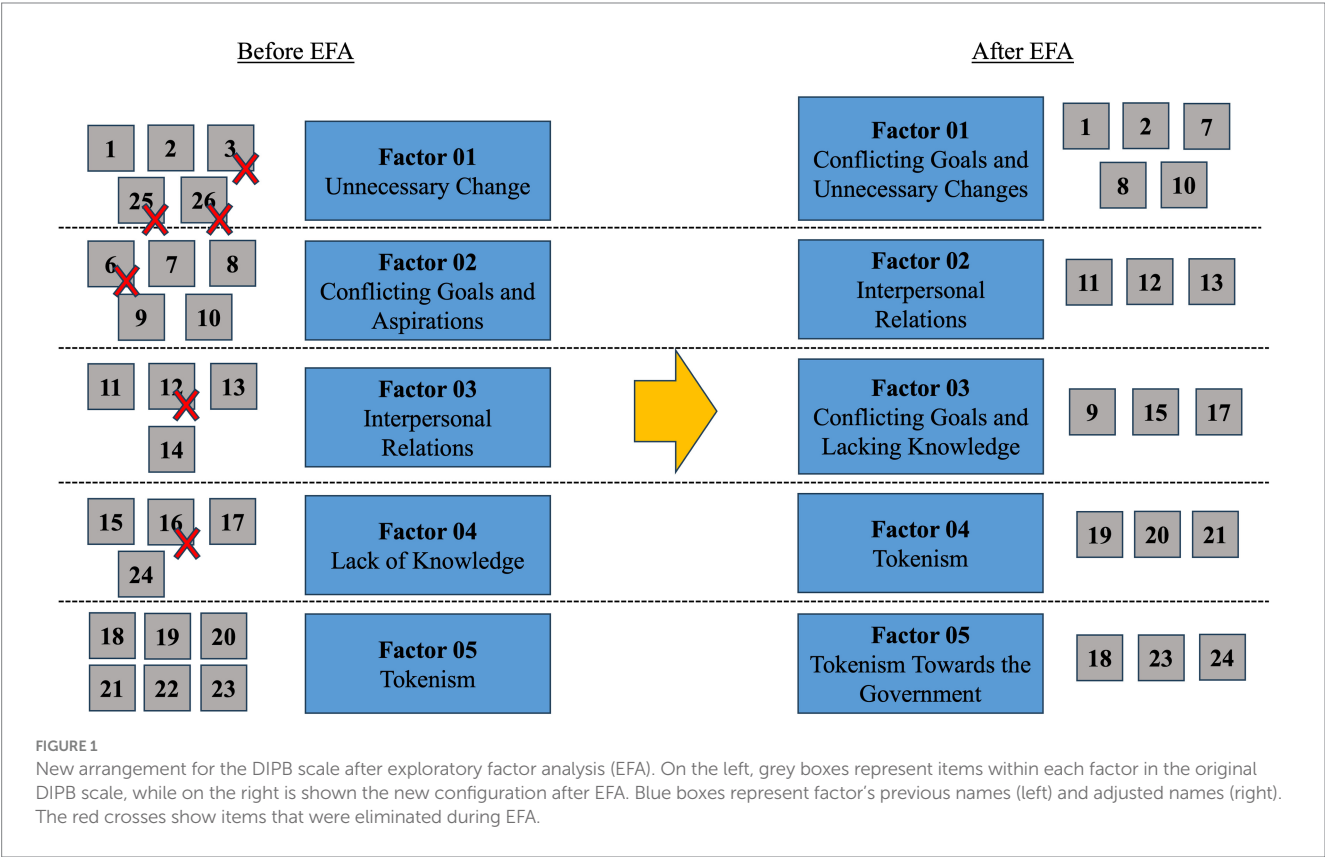
TABLE 2 Original DIPB scale and its adapted version containing Cronbach's alpha (α) for its factors.

Original—Psychological barrier factors and items		
Factor 1: Change unnecessary		
1	There's not much point in me making this change because I feel confident that technological innovators will solve environmental problems.	
2	Humans are powerless when it comes to saving the Earth, so there is no need to change.	
3	These problems are so far in the future, so there is no need to act.	
25	There's a need for change because I believe that a serious environmental problem exists.	
26	What happens at the industrial level makes my changing insignificant.	
Factor 2: Conflicting goals and aspirations		
6	Making this change would interfere too much with my other goals in life.	
7	I'm concerned that this change will take up too much of my time.	
8	I can't change because I'm invested in my current lifestyle.	
9	These issues are important to me but it's too hard to change my habits.	
10	I haven't changed because I'm afraid this wouldn't work.	
Factor 3: Interpersonal relations		
11	Making this change would be criticized by those around me.	
12	I would be letting certain people down if I made this change.	
13	I'm worried that my friends would disapprove if I made this change.	
14	If I made the necessary change, I would probably be embarrassed when others noticed what I was doing.	
Factor 4: Lacking knowledge		
15	There's so much information out there that I am confused about how to make this change.	
16	I don't understand enough of the details about how to make this change.	
17	I'd like to change but I'm not sure where to begin.	
24	It's the government's responsibility to regulate this change.	
Factor 5: Tokenism		
18	The pro-environmental efforts that I currently engage in make further changes unnecessary.	
19	I've already made sacrifices to solve environmental problems, so there is no need for me to do more.	
20	I previously have made important effort in this, so there is no need for me to make further changes.	
21	My environmental actions already make enough of a difference.	
22	It's not fair for me to change when really, it's industry that's causing the majority of environmental problems.	
23	The government should make it easier for me to change, if it really has the best interest of the environment in mind.	
Adapted—Psychological barrier factors and items		α
Factor 1: Conflicting goals and unnecessary changes		0.76
7	I believe that these changes would take too much of my time.	
10	I will not change because that would not work.	
2	I do not need to change because humans are not capable of saving planet Earth.	
8	I already invested too much on my way of living, thus I cannot change.	
1	It makes no sense in changing because technology is going to solve this problem in the future.	
Factor 2: Interpersonal relations		0.72
14	I would be embarrassed when others noticed that I have changed.	
11	If I change, I would be criticized by people around me.	
13	I am concerned that my friends would not approve if I changed.	
Factor 3: Conflicting goals and lacking knowledge		0.58
9	These issues are important for me, but it is too difficult to change my habits.	
17	I would like to change, but I really do not know where to start.	
15	I get confused about how to make this change because there is too much information around.	

(Continued)

TABLE 2 (Continued)

Adapted—Psychological barrier factors and items		α
Factor 4: Tokenism		0.73
20	I have already made many sacrifices for the environment, and now I do not need to do anything.	
21	I have already did too much in the past, not making it necessary to change even further.	
19	What I do for the environment is enough.	
Factor 5: Tokenism toward the government		0.66
23	It is not fair that I have to change, considering that major environmental problem causes are from industries and big companies.	
24	The government should facilitate this change if it really is concerned about the environment.	
18	The responsibility of commanding this change is from the government.	



Item 01's average score was 14.72 and 94 students achieved maximum score (20.93%). Although students were able to easily identify an adult mosquito from an egg, they struggled to differentiate larvae and pupae stages, thus reducing the item's score ($n = 337$, 75.05%).

Item 02's average score was 20.54 and 221 students achieved maximum score (49.22%). Items correctly related to mosquito's reproduction that were most identified by students were leaving the water tank open ($n = 435$, 96.88%), plant vases ($n = 388$, 86.41%), disposed tires ($n = 376$, 83.74%), and rubbish incorrectly disposed ($n = 337$, 75.05%). At the same time, some actions that are not related to the mosquito were also mentioned as to be possibly related to it, like leaving the water tank closed ($n = 32$, 7.12%), rats and mice ($n = 27$, 6.01%), sneezing ($n = 15$, 3.34%), and holding hands ($n = 6$, 1.33%).

Item 03's average score was 14.28 and 111 students achieved maximum score (24.72%). While most students were able to identify

Zika ($n = 352$, 78.39%) and Chikungunya ($n = 360$, 80.17%) as possible diseases to be transmitted by *Aedes aegypti*, a smaller number was able to identify Yellow fever ($n = 276$, 61.46%). At the same time, other diseases, not related to *Aedes aegypti* were also mentioned as to be possibly transmitted by the mosquito, as in the flu ($n = 149$, 33.18%), AIDS ($n = 60$, 13.36%), COVID ($n = 17$, 3.78%), tetanus ($n = 16$, 3.56%), and diabetes ($n = 10$, 2.22%).

Item 04's average score was 19.39 and 189 students achieved maximum score (42.09%). While most students were able to identify the importance of leaving the water tank closed to prevent mosquitos laying eggs ($n = 432$, 96.21%), other options were also mentioned, like avoiding water accumulation ($n = 402$, 89.53%), using sand on water vases ($n = 327$, 72.82%), and proper trash disposal ($n = 298$, 66.36%). At the same time, some behaviors that are not related to prevent mosquito's reproduction were also selected by students, like getting in

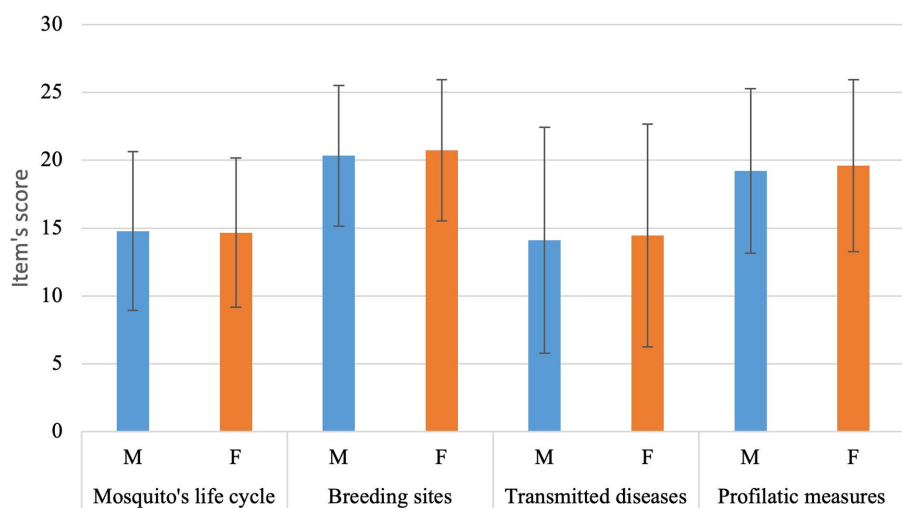


FIGURE 2
Average score for each of the four items in the Dengue fever's test split into male (M) and female (F) (i.e., separated by the topics each referred to).

contact with rusted objects ($n=31$, 6.9%), wearing a mask ($n=23$, 5.12%), avoid hugging people ($n=15$, 3.34%), sugar consumption ($n=11$, 2.44%), and physical activities ($n=4$, 0.8%).

There was no significant difference between schools on the total result (Kruskal-wallis, $p=0.9513$). When evaluating items separately, no difference could be observed between different schools as well (item 01 $p=0.3266$, item 02 $p=0.729$, item 03 $p=0.4692$, item 04 $p=0.8303$). The total result also did not differ between genders (Kruskal-Wallis, $p=0.2614$).

Study 2—Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis was conducted to verify if items were consistent to its factors. Several indices were used to evaluate model fit (Table 3). Factorial loadings indicate that most variables have a strong association with its respective factors, while correlation between factors suggest a moderate relation and a good distinction between them (Figure 3).

The total data collected by the DIPB scale initially pointed those items from factors 3 and 5 showed a higher level of agreement by students (Figure 4).

This pattern was maintained when analyzing the categories individually (i.e., schools, gender, and Dengue's test result), with significant differences being presented below.

TABLE 3 Model fit criteria for the five-item model after CFA.

Model	Model fit indices			
	χ^2/df	RMSEA	CFI	GFI
Five-factors model	2.081	0.052	0.928	0.941

The table presents (1) chi-square to the degrees of freedom ratio (χ^2/df , a ratio between 2 and 3 is considered indicative of a good data-model fit), (2) Root Mean Square Error of Approximation (RMSEA, values close to 0.05 indicate a good fit), (3) Comparative Fit Index (CFI, values above 0.90 indicate a good fit), and (4) Goodness of Fit Index (GFI, values close to 0.95 are considered adequate).

Data was initially split into four categories based on Dengue's test results (i.e., low score, medium score, high score, and top-high score). Students with a low or medium score on the Dengue's test presented a higher level of agreement for factors 1 and 2 (Table 4).

There was no significant difference between male and female answers, with a subtle tendency for factor 4 ($p=0.0664$). Inside this factor, item 19 showed significant difference (p -value: 0.0464, male mean: 1.8984, male SD: 0.0829, female mean 1.6857, female SD: 0.0677), item 20 and 21 showed no significant difference.

Comparison between schools showed significant difference for factors 2 and 3 between school number two when compared to school number three (factor 02: **, factor 03), four (factor 02: **), five (factor 02: *), six (factor 02: **, factor 03: **), and seven (factor 02: *, factor 03: *) (Table 5).

For factors three, four and five, items 17, 19, and 24 were analyzed separately, due to a higher level of agreement when compared to other items within its own factor. Each of these items showed significant difference ($p<0.001$) when compared to the other two.

Discussion

Study 1—Exploratory Factor Analysis

For the EFA, the present study identified a rearrange of the items and elimination of five of them. This variation may be explained by three different reasons. First, previous studies that validated the DIPB scale used a sample of undergraduate students, while here respondent's age mean was 12 years old. This may affect how they interpret the items and connect to them (Boateng et al., 2018; Chwalow, 1995). Secondly, how people relate to the *Aedes aegypti* and Dengue fever situation is something quite specific for the countries that need to address this issue (Gubler and Clark, 1996). Third, different languages may not encapsulate the complete original meaning of the sentence, in which some subtle differences may affect the final interpretation of the item (Mager et al., 2018; Malá, 2013; Xian, 2008). Thus, although the DIPB scale was originally developed to be used for different

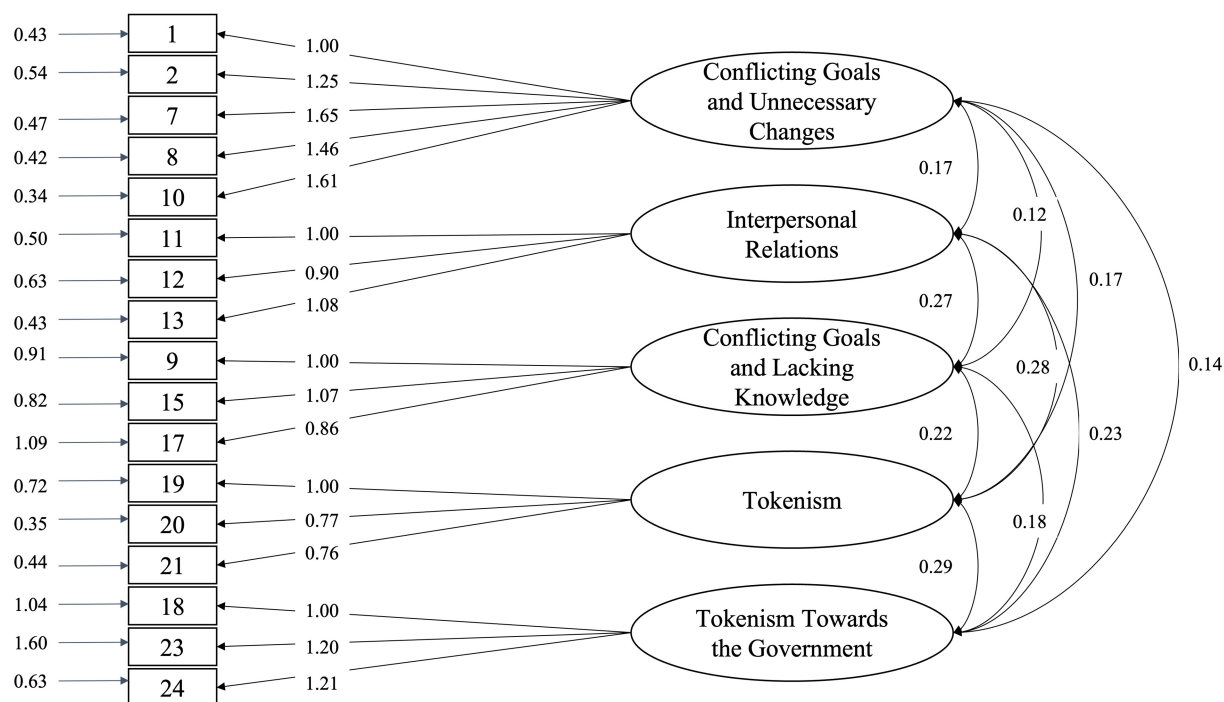


FIGURE 3
Five-factor model after item removal ($n = 449$). Arrows pointing from factors to items show factorial loadings, while arrows between factors show correlation, and arrows to the left, pointing to items show their error terms.

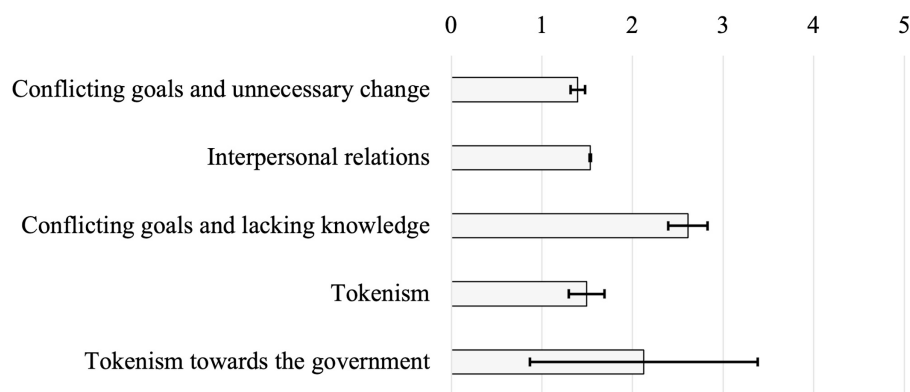


FIGURE 4
Mean barrier agreement's scores for each of the analyzed factors ($n = 449$).

ecological contexts, some adaptations may be needed depending on the target group and ecological context that is being analyzed.

Study 2—Dengue fever test results

Many papers have been made trying to propose new approaches toward environmental education actions to fight the mosquito (Espinoza-Gómez et al., 2002; Fernandes et al., 2023; Lloyd et al., 1994).

By the answers given on the test, students showed that they are able to recognize situations and actions that are related to mosquito's

reproduction. The obtained data confirms what was expected by literature, where students understand what are the basic underlying mechanisms behind *Aedes aegypti*'s reproduction and how to stop it (Cruz and Santana, 2017; Silva et al., 2018). No significant difference was observed between schools, suggesting that the environmental actions that are being taken to educate the population are distributed homogeneously.

Although these actions may present positive results, they are still not enough to control mosquito's proliferation (de Souza et al., 2021). One key aspect that may justify this scenario and has been perceived in recent literature is the conflict between people's and government's responsibilities (lack of maintenance of public spaces by the

TABLE 4 Means and standard deviation (SD) of agreement for each factor based on Dengue's test results.

		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Total	Mean	1.3877	1.5208	2.6003	1.4823	2.1269
	SD	0.0184	0.0285	0.0346	0.0268	0.0381
Lower score	Mean	1.422	1.7553	2.6758	1.5259	2.1376
	SD	0.0374	0.0664	0.0681	0.0542	0.0727
Medium score	Mean	1.4743	1.4352	2.5785	1.5509	2.1487
	SD	0.0369	0.0467	0.0619	0.0524	0.0677
High score	Mean	1.3421	1.513	2.6.223	1.4.843	2.1901
	SD	0.0291	0.0491	0.0627	0.0466	0.0715
Top high score	Mean	1.3296	1.4322	2.5567	1.3919	1.9853
	SD	0.0369	0.0548	0.0746	0.0496	0.0757
Low vs. high		–	**	–	–	–
Medium vs. high		*	–	–	–	–
Top high vs. high		–	–	–	–	–
Medium vs. low		–	***	–	–	–
Top high vs. low		–	**	–	–	–
Top high vs. medium		*	–	–	–	–

Low score = <60.35; Medium score = between 60.35 and 70.8; High score = between 70.8 and 79.1; and Top-high score = above 79.1 and Tukey's comparison between groups. Values that are in bold presented significant differences when compared to other groups (i.e., * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).

TABLE 5 Means and standard deviation (SD) of the five factors for each of the 11 schools.

School		Factor 05	Factor 04	Factor 03	Factor 02	Factor 01
#1	Mean	2.192	1.494	2.750	1.667	1.438
	SD	0.103	0.066	0.098	0.092	0.048
#2	Mean	2.000	1.561	2.982	1.860	1.547
	SD	0.121	0.100	0.120	0.124	0.077
#3	Mean	2.271	1.479	2.500	1.344	1.313
	SD	0.150	0.102	0.130	0.071	0.056
#4	Mean	2.180	1.573	2.627	1.373	1.320
	SD	0.106	0.080	0.102	0.057	0.045
#5	Mean	1.951	1.486	2.528	1.458	1.388
	SD	0.106	0.079	0.100	0.086	0.060
#6	Mean	2.348	1.338	2.453	1.433	1.352
	SD	0.102	0.054	0.082	0.060	0.046
#7	Mean	2.000	1.362	2.333	1.348	1.330
	SD	0.149	0.090	0.114	0.085	0.061
#8	Mean	2.194	1.431	2.514	1.556	1.392
	SD	0.161	0.108	0.134	0.122	0.071
#9	Mean	1.935	1.529	2.710	1.623	1.457
	SD	0.110	0.088	0.109	0.097	0.062
#10	Mean	2.049	1.605	2.457	1.519	1.296
	SD	0.133	0.123	0.124	0.111	0.057
#11	Mean	2.103	1.603	2.706	1.667	1.462
	SD	0.110	0.083	0.113	0.094	0.056

Values that are in bold presented significant differences when compared to school #2 (i.e., * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).

government and lack of management on local dumpsters, for example) (Chiaravalloti et al., 2002; Donalisio et al., 2001; Heymann and Dar, 2014; de Oliveira and Lima, 2013; Rangel-S, 2008; Reis et al., 2013).

The two items that presented the lowest score were Items 01 and 03. The main reason for the first one was that students were not able to differentiate larval and pupal stages. Even though this reduced the item's mean, it is hypothesized that it would not represent a meaningful difference on how people act to prevent mosquito's reproduction. Mainly because both stages, larvae and pupae, share the same habitat (i.e., stagnant water).

Regarding Item 03, many students believe that the mosquito may transmit diseases like the flu and AIDS. This information may be relevant for designing future educational campaigns, both for preventing *Aedes aegypti*'s reproduction and Sexually Transmitted Infections (STI's).

Items 02 and 04, related to the prophylactic measures necessary to reduce mosquito's population and identifying areas where females lay their eggs presented the highest scores. This suggests that the educational actions taken by the government and schools are capable of addressing these topics to a younger audience.

Study 2—DIPB's results

Based on the DIPB's scale, results suggest that current educational campaigns seem to be unable to address all analyzed barriers. Students that scored higher on Dengue's test seemed to present less barriers toward adopting PEB for factors 01 and 02 (i.e., Conflicting goals and unnecessary changes and Interpersonal relations), but no significant difference could be observed for the other factors. Thus, teaching about the mosquito's life cycle and what has to be done to prevent its proliferation (e.g., avoiding the accumulation of clean water in multiple spaces, like flower plates, vases, bottles, roof gutter, and garbage disposal) seems to not be enough to possibly change the behavior of some participants, considering that some psychological barriers are not being considered.

Overcoming these barriers seem to be the greatest challenge faced nowadays. The K&A model (Kollmuss and Agyeman, 2010) was created to identify internal (i.e., Personality traits and value system) and external factors (i.e., Infrastructure, Political, Social, and Cultural factors, and Economic situation) that may impose barriers to PEB. This model is being tested in recent years (Graves and Roelich, 2021) and some of these factors could justify the barriers identified in this study.

Factors 03 and 05 (i.e., Conflicting goals and lacking knowledge and Tokenism toward the government) presented the highest level of agreement by students overall. The items that presented the higher level of agreement were 17 (factor 3, mean: 3.0098, *I would like to change, but I really do not know where to start*) and 24 (factor 5, mean: 2.6683, *the government should facilitate this change if it really is concerned about the environment*). Considering the presented results, and what has been described in previous papers, it seems to be imperative that educational programs continue to address and reinforce PEB by the population, but also facilitates the communication to the local government, making it clear the responsibilities between internal and external factors. It is proposed that this communication needs to address public spaces management and general complaints.

Wu et al. (2023), states the relevance of local governments in regulating and empowering the population, mainly by resource mobilization and political processes for residents to manifest desired PEB. Other studies have also identified how the role of perceived government is able to influence PEB (Berglund and Matti, 2006; Lavergne et al., 2009).

School # 2 presented higher values for factor 2 and 3, presenting a significant difference when compared to other schools, even though there was no significant difference this particular institution and other schools for the Dengue's questionnaire. The school is located in the biggest city's neighborhood, attending students from a variety of regions. This result may be explained by the access those students have to educational campaigns from the government and media, but more studies are necessary to understand this variation. To better understand it, a multi-variable analysis is suggested, where aspects like (1) government's presence in the region (i.e., parks maintenance and waste disposal), (2) frequency of sanitary agents visits, and (3) socioeconomically aspects (Corral-Verdugo and Pinheiro, 1999; de Souza et al., 2021) are suggested and may be responsible for eliciting these psychological barriers.

This pattern repeated itself even with students that scored high on Dengue's test, showing that they understand what is necessary to inhibit mosquito's reproduction, but maybe do not feel in the position to take action. Therefore, environmental education programs and actions need to address these barriers to encourage students to take action to protect the environment and prevent the proliferation of Dengue mosquitoes.

Suggestions for future environmental education projects

Environmental education projects and actions developed in the last decades have distanced themselves from a conservationist point of view to a more critical perspective. In a research on developed papers from between 2003 and 2007, (Pato et al., 2009), identified that a socioenvironmental approach, that recognizes political and cultural aspects as part of a new epistemological perspective is notable. Thus, creating new ways to build positive connections between the population and natural environment seems to be the current tendency (Ardoin et al., 2020; Li et al., 2024; San Jose and Nelson, 2017).

When considered the actions toward inhibiting Dengue mosquitoes' reproduction, a practical approach is, in many cases, adopted (Luz et al., 2024; Rosa et al., 2020). One of the reasons for that is the large scale in which this subject is engaged, through the television, radio, educational campaigns, and others. These procedures repeat themselves in different places, with almost no change on how they occur.

In these strategies, the participant, a mere receptor of information, must replicate the instructions in their houses or region where they live. The change on how they relate to the environment, government, and how information and experiences are exchanged is mostly disconsidered. It is believed that one of the main reasons for that is the use of indicators to measure the efficiency of these campaigns. The term efficiency is used on this study because of the relation between educational campaigns and reduction of cases reported or breeding

sites identified by public agents (Arantes et al., 2023; Caregnato et al., 2008; Gonçalves et al., 2023; Luz et al., 2024; Sulistyawati, 2024).

Thus, it is initially suggested a segmentation between the different goals an environmental education project or action on that matter might have. While some actions may focus in informing about the mosquito, symptoms and how to prevent its proliferation (dos Santos et al., 2023), others must focus on creating more powerful connections between the population, environment and government (Busato et al., 2024; Martín et al., 2024; de Oliveira and Lima, 2013; de Souza Pinto et al., 2013). By doing that, and clearly establishing the responsibilities between the many responsible agents of that phenomenon, it is expected to diminish the barriers identified in the studies here presented.

This seems to be general consensus of what has already been described in recent literature (Costa and dos Anjos Carneiro-Leão, 2021; dos Santos and Vieira, 2023). A recently published review on five decades of Dengue's prevention and control in Singapore showed four key features that were responsible for significantly reducing the mosquito index, where coordinated inter-sectoral cooperation is one of them (Ho et al., 2023).

To inform the population about individual, collective, and governmental responsibilities, creating ways to connect those points may be an important step in reducing the barriers here presented. However, not only that, but also to find ways to create positive connections between different segments of society and nature, strengthening values and beliefs that are closely related to PEB's is essential to create long lasting changes (de Lima and Pato, 2021; Portus et al., 2024; Tucholska et al., 2024; Goulart et al., 2016), points out that the lack of information, absence of environmental education campaigns, rapid proliferation of the mosquito, and lack of governmental preventive actions are among the main factors that weakens public policy, even in regions with adequate budgets to fight the disease. It is then perceived the environmental education programs cannot be reduced to isolated actions of informing the population, but something that creates a mosaic of actions and projects, with different goals, capable of aiming internal and external factors for various environmental challenges.

Conclusion

This work aimed to identify possible psychological barriers behind the adoption of pro-environmental behaviors expected to reduce *Aedes aegypti*'s population. For that, a scale for psychological barriers was initially validated for Brazilian children, and then tested across multiple variables. This is the first study to assess psychological barriers toward *A. aegypti* using a quantitative methodology. Thus, considering the nature of an exploratory study and subject's novelty, some considerations and propositions are made for future investigations. For future research, understanding if different target groups (i.e., age group, geographical location, education levels and others) present similar barriers, and comparing different strategies of environmental education projects and actions seems to be an important step to validate possible trends in psychological barriers toward PEB's on that matter.

The DIPB scale had to be adjusted after EFA and some factors were rearranged. It is suggested that new adaptations may be needed to accommodate the subtle variables that are present in different geographical regions, linguistic aspects, and target group (i.e., age,

education level, and economical background). Also, regional differences and the impact caused by *A. aegypti* infestation and its correlated diseases may affect the barriers observed in different regions.

Dengue's questionnaire showed that students know what has to be done to prevent mosquito's proliferation, and how water is connected to its life cycle. However, the diseases that may be transmitted by it, besides Dengue fever, still seem to be confusing.

Students that scored lower in Dengue's questionnaire presented more barriers when compared to those who scored higher for factors 01 (Conflicting goals and unnecessary changes) and 02 (Interpersonal relations). Educational programs seem to be effective to reduce these barriers, even though some are still present.

On the adapted DIPB scale, students presented a higher agreement on items 17 (*I would like to change, but really do not know where to start*), 19 (*What I do for the environment is enough*), and 24 (*The government should facilitate this change if it really is concerned about the environment*). These results suggests that future educational campaigns should build different actions that focuses on addressing both internal and external factors, creating a mosaic of projects, with different goals, each aiming different environmental challenges.

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 humans were approved by the Comitê de Ética em Pesquisa em Ciências Humanas e Sociais (CEP/CHS) of Universidade de Brasília, C.A.A.E., nº 66395022.8.0000.5540. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

PS: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Conceptualization. LL: Writing – review & editing, Validation, Supervision, Software, Methodology, Formal analysis. CL: Writing – review & editing, Supervision, Project administration, Conceptualization.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated

organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Arantes, A. P. F., da Silva, L. M., and da Silva, L. C. (2023). Projeto “Xô Dengue”: iniciativa de educação ambiental em um colégio da rede pública de ensino do estado de Goiás. *Rebena Rev Brasileira Ensino Aprendizagem* 5, 69–78.
- Ardoin, N. M., Bowers, A. W., and Gaillard, E. (2020). Environmental education outcomes for conservation: a systematic review. *Biol. Conserv.* 241:108224. doi: 10.1016/j.biocon.2019.108224
- Berglund, C., and Matti, S. (2006). Citizen and consumer: the dual role of individuals in environmental policy. *Environ. Politics* 15, 550–571. doi: 10.1080/09644010600785176
- Best, H., and Mayerl, J. (2013). Values, beliefs, attitudes: an empirical study on the structure of environmental concern and recycling participation. *Soc. Sci. Q.* 94, 691–714. doi: 10.1111/ssqu.12010
- Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quinonez, H. R., and Young, S. L. (2018). Best practices for developing and validating scales for health, social, and behavioral research: a primer. *Front. Public Health* 6:149. doi: 10.3389/fpubh.2018.00149
- Bouranta, N., Chitiris, L., and Paravantis, J. (2009). The relationship between internal and external service quality. *Int. J. Contemp. Hosp. Manag.* 21, 275–293. doi: 10.1108/09596110910948297
- Bouzd, M., Brainard, J., Hooper, L., and Hunter, P. R. (2016). Public health interventions for Aedes control in the time of Zikavirus— a meta-review on effectiveness of vector control strategies. *PLoS Negl. Trop. Dis.* 10:e0005176. doi: 10.1371/journal.pntd.0005176
- Brazil (2023). Situação Epidemiológica—Mosquito da Dengue [Federal website]. Ministério da Saúde. Available at: <https://www.gov.br/saude/pt-br/assuntos/saude-de-a-a-z/d/dengue/situacao-epidemiologica> (Accessed October 30, 2023).
- Brazil (2024). Notícia oficial sobre a Dengue [Governo Federal]. Ministério da Saúde. Available at: <https://www.gov.br/saude/pt-br/assuntos/noticias/2024/marco/se-nao-houver-uniao-nao-havera-saude-declara-ministra-nisia-no-dia-d-contra-a-dengue> (Accessed March 12, 2024).
- Brusich, M., Grieco, J., Penney, N., Tisgratog, R., Ritthison, W., Chareonviriyaphap, T., et al. (2015). Targeting educational campaigns for prevention of malaria and dengue fever: an assessment in Thailand. *Parasit. Vectors* 8:43. doi: 10.1186/s13071-015-0653-4
- Busato, M. A., Schabat, F. M., and Lutinski, J. A. (2024). Educação em Saúde Ambiental e Percepção de Gestores No Controle Populacional Do Mosquito Aedes Aegypti Em Santa Catarina.
- Caregnato, F. F., de Fetzter, L. O., Weber, M. A., and Guerra, T. (2008). Educação Ambiental como estratégia de prevenção a dengue no bairro do Arquêpelo, Porto Alegre, RS, Brasil. *Rev. Bras. Biociências* 6:2.
- Chiaravalloti, V. B., de Moraes, M. S., Chiaravalloti Neto, F., Conversani, D. T., Fiorin, A. M., Barbosa, A. A. C., et al. (2002). Avaliação sobre a adesão às práticas preventivas do dengue: O caso de Catanduva, São Paulo, Brasil. *Cad. Saude Publica* 18, 1321–1329. doi: 10.1590/S0102-311X2002000500025
- Chiaravalloti Neto, F. (1997). Conhecimentos da população sobre dengue, seus vetores e medidas de controle em São José do Rio Preto, São Paulo. *Cad. Saude Publica* 13, 447–453. doi: 10.1590/S0102-311X1997000300020
- Chiaravalloti Neto, F., de Moraes, M. S., and Fernandes, M. A. (1998). Avaliação dos resultados de atividades de incentivo à participação da comunidade no controle da dengue em um bairro periférico do Município de São José do Rio Preto, São Paulo, e da relação entre conhecimentos e práticas desta população. *Cad. Saude Publica* 14, S101–S109. doi: 10.1590/S0102-311X1998000600009
- Chwalow, A. J. (1995). Cross-cultural validation of existing quality of life scales. *Patent Educ. Couns.* 26, 313–318. doi: 10.1016/0738-3991(95)00767-T
- Claro, L. B. L., Tomassini, H. C. B., and Rosa, M. L. G. (2004). Prevenção e controle do dengue: Uma revisão de estudos sobre conhecimentos, crenças e práticas da população. *Cad. Saude Publica* 20, 1447–1457. doi: 10.1590/S0102-311X2004000600002
- Corraliza, J. A., and Berenguer, J. (2000). Environmental values, beliefs, and actions: a situational approach. *Environ. Behav.* 32, 832–848. doi: 10.1177/00139160021972829
- Corral-Verdugo, V., and Pinheiro, J. Q. (1999). Condições para o estudo do comportamento pró-ambiental. *Estudos Psicol.* 4, 7–22. doi: 10.1590/S1413-294X1999000100002
- Costa, J. S., and dos Anjos Carneiro-Leão, A. M. (2021). Campanhas sanitárias como instrumentos da educação em saúde no Brasil: Algumas reflexões para uma educação popular em saúde. *Rev. Sustinere* 9, 333–351. doi: 10.12957/sustinere.2021.49818
- Cruz, A. M. J., and Santana, A. R. (2017). A Educação Ambiental Como Estratégia De Combate Ao Aedes AEGYPTI.
- de Lima, V. F., and Pato, C. (2021). Educação Ambiental: aspectos que dificultam o engajamento docente em escolas públicas do Distrito Federal. *Educar Rev.* 37:e78223. doi: 10.1590/0104-4060.78223
- de Oliveira, J. C., and Lima, S. C. (2013). Mobilização comunitária e vigilância em saúde no controle de vetores, estratégias da promoção da saúde: conquistas e desafios. *Rev. Educ. Popular* 12:1. doi: 10.14393/REP-2013-23029
- de Souza, T. G. B., de Arruda, E. J., Machado, A. M., and de Souza, A. P. (2021). Educação em saúde no controle do *Aedes aegypti* – da teoria à prática. *Res. Soc. Dev.* 10:9. doi: 10.33448/rsd-v10i9.17912
- de Souza Pinto, P., de Oliveira Pinto, F., and Duarte, S. C. (2013). A Dengue e sua relação com Educação Ambiental no município de Quissamã/RJ. *Rev. Científica Faculdade Med. Campos* 8, 14–18. doi: 10.29184/1980-7813.rcfmc.76.vol.8.n1.2013
- Donalisio, M. R., Alves, M. J. C. P., and Visockas, A. (2001). Inquérito sobre conhecimentos e atitudes da população sobre a transmissão do dengue—Região de Campinas São Paulo, Brasil—1998. *Rev. Soc. Bras. Med. Trop.* 34, 197–201. doi: 10.1590/S0037-86822001000200008
- dos Santos, T. A., Menezes, R. O., Oliveira, B. D., and Queiroz, M. S. (2023). Jogo Didático da Dengue Como Proposta Para Uma Educação Ambiental. Anais da III Semana Integrada Do Cerrado. Available at: <https://publicacoes.unifimes.edu.br:443/index.php/semana-integrada-cerrado/article/view/3063> (Accessed June 13, 2024).
- dos Santos, L. B., and Vieira, R. L. A. (2023). Estratégias de Prevenção e Controle da Dengue, Chikungunya e Zika no Município de Cruz das Almas-BA. *Geografia* 32, 49–64. doi: 10.5433/2447-1747.2023v32n2p49
- Espinoza-Gómez, F., Hernández-Suárez, C. M., and Coll-Cárdenas, R. (2002). Educational campaign versus Malathion spraying for the control of *Aedes aegypti* in Colima, Mexico. *J. Epidemiol. Commun. Health* 56, 148–152. doi: 10.1136/jech.56.2.148
- Fernandes, W. R., Pimentel, V. R. D. M., Sousa, M. F. D., and Mendonça, A. V. M. (2023). Programa Saúde na Escola: Desafios da educação em saúde para prevenir Dengue, Zika e Chikungunya. *Saúde em Debate* 46, 179–189. doi: 10.1590/0103-11042022E313
- Gaspar, R. (2013). Understanding the reasons for behavioral failure: a process view of psychosocial barriers and constraints to pro-ecological behavior. *Sustain. For.* 5, 2960–2975. doi: 10.3390/su5072960
- Gifford, R. (2011). The dragons of inaction: psychological barriers that limit climate change mitigation and adaptation. *Am. Psychol.* 66, 290–302. doi: 10.1037/a0023566
- Gonçalves, E. C. P., Kligerman, D. C., Cohen, S. C., and Kleinubing, N. V. (2023). School health program: intervention project against dengue in Matinhos, state of Paraná, Brazil. *Saúde Em Debate* 46, 190–200. doi: 10.1590/0103-11042022e314
- Goulart, S. O., Dornelles, M., de Almeida, D. M., Corrêa, J. S., and Lopes, L. F. D. (2016). Dengue no Brasil: gestão de políticas públicas de controle e erradicação. *Rev. Estudo Debate* 23:2. doi: 10.22410/issn.1983-036X.v23i2a2016.1152
- Graves, C., and Roelich, K. (2021). Psychological barriers to pro-environmental behaviour change: a review of meat consumption behaviours. *Sustain. For.* 13:21. doi: 10.3390/su132111582
- Grilli, G., and Curtis, J. (2021). Encouraging pro-environmental behaviours: a review of methods and approaches. *Renew. Sust. Energ. Rev.* 135:110039. doi: 10.1016/j.rser.2020.110039
- Gubler, D. J., and Clark, G. G. (1996). Community involvement in the control of *Aedes aegypti*. *Acta Trop.* 61, 169–179. doi: 10.1016/0001-706X(95)00103-L
- Gutiérrez, A., Sofia, L., Patiño, P., and Enrique, L. (2022). Adaptation of the dragons of inaction psychological barriers (DIPB) scale in a Colombian population. Available at: <https://www.proquest.com/openview/293df120d160c489613f97438441bb84/1?pq-origsite-gscholar&cbl=5517080> (Accessed March 19, 2022).
- Heymann, D. L., and Dar, O. A. (2014). Prevention is better than cure for emerging infectious diseases. *BMJ* 348:g1499. doi: 10.1136/bmj.g1499
- Ho, S. H., Lim, J. T., Ong, J., Hapuarachchi, H. C., Sim, S., and Ng, L. C. (2023). Singapore's 5 decades of dengue prevention and control—implications for global dengue control. *PLoS Negl. Trop. Dis.* 17:e0011400. doi: 10.1371/journal.pntd.0011400
- Ho, T. Q., Nie, Z., Alpizar, F., Carlsson, F., and Nam, P. K. (2022). Celebrity endorsement in promoting pro-environmental behavior. *J. Econ. Behav. Organ.* 198, 68–86. doi: 10.1016/j.jebo.2022.03.027
- Hosseini, S., Oliva-Ramírez, J., Vázquez-Villegas, P., Rodríguez-García, A., Muñoz-Soto, R. B., Aghamohammadi, N., et al. (2018). Dengue fever: a worldwide threat an overview of the infection process, environmental factors for a global outbreak,

- diagnostic platforms and vaccine developments. *Curr. Top. Med. Chem.* 18, 1531–1549. doi: 10.2174/1568026618666181105130000
- Iglesias, F., Caldas, L., and Rabelo, L. (2014). Negando ou subestimando problemas ambientais: barreiras psicológicas ao consumo responsável. *Psico* 45:377. doi: 10.15448/1980-8623.2014.3.17316
- Junior, V. L. P., Luz, K., Parreira, R., and Ferrinho, P. (2015). Zika virus: a review to clinicians. *Acta Medica Port.* 28, 760–765. doi: 10.20344/amp.6929
- Karp, D. G. (1996). Values and their effect on pro-environmental behavior. *Environ. Behav.* 28, 111–133. doi: 10.1177/0013916596281006
- Kollmuss, A., and Agyeman, J. (2010). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* 8, 239–260. doi: 10.1080/13504620220145401
- Kraemer, M. U., Sinka, M. E., Duda, K. A., Mylne, A. Q., Shearer, F. M., Barker, C. M., et al. (2015). The global distribution of the arbovirus vectors *Aedes aegypti* and *Ae. Albopictus*. *eLife* 4:e08347. doi: 10.7554/eLife.08347
- Lacroix, K., Gifford, R., and Chen, A. (2019). Developing and validating the dragons of inaction psychological barriers (DIPB) scale. *J. Environ. Psychol.* 63, 9–18. doi: 10.1016/j.jenvp.2019.03.001
- Lange, F., and Dewitte, S. (2019). Measuring pro-environmental behavior: review and recommendations. *J. Environ. Psychol.* 63, 92–100. doi: 10.1016/j.jenvp.2019.04.009
- Lapa, L. G. (2019). Mapeamento de valores e compreensão do jeito brasileiro em estudantes do ensino fundamental do Distrito Federal. Available at: <https://repositorio.unb.br/handle/10482/35768> (Accessed June 16, 2024).
- Lavergne, K., Sharp, E., Pelletier, L., and Holtby, A. (2009). The role of perceived government style in the facilitation of self-determined and non-self-determined motivation for pro-environmental behavior. *J. Environ. Psychol.* 30, 169–177. doi: 10.1016/j.jenvp.2009.11.002
- Li, Y., Yang, D., and Liu, S. (2024). The impact of environmental education at Chinese universities on college students' environmental attitudes. *PLoS One* 19:e0299231. doi: 10.1371/journal.pone.0299231
- Lloyd, L. S., Winch, P., Ortega-Canto, J., and Kendall, C. (1994). The design of a community-based health education intervention for the control of *Aedes aegypti*. *Am. J. Tropical Med. Hygiene* 50, 401–411. doi: 10.4269/ajtmh.1994.50.401
- Lucas, K., Brooks, M., Darnton, A., and Jones, J. E. (2008). Promoting pro-environmental behaviour: existing evidence and policy implications. *Environ. Sci. Pol.* 11, 456–466. doi: 10.1016/j.envsci.2008.03.001
- Luz, D. F., da Silva, D., da Filho, W. C. S., Morales, K. G., and Borges, R. B. (2024). A educação ambiental e seu impacto no combate aos vetores transmissores de doenças. *Rev. Pantaneira* 23, 88–97.
- Mager, M., Mager, E., Medina-Urrea, A., Meza, I., and Kann, K. (2018). Lost in translation: analysis of information loss during machine translation between polysynthetic and fusional languages. In Proceedings of the Workshop on Computational Modeling of Polysynthetic Languages. Santa Fe, New Mexico, USA: Association for Computational Linguistics, pp. 73–83.
- Malá, M. (2013). Translation counterparts as markers of meaning: the case of copular verbs in a parallel English–Czech corpus. *Lang. Contrast* 13, 170–192. doi: 10.1075/lic.13.2.03mal
- Martin, G. S., Aronson, C., Karagueuzian, J., and Grimson, R. (2024). Educación Ambiental en clave territorial: colaboración escuela secundaria-universidad para el intercambio de experiencias y saberes científicos en el Conurbano Bonaerense. *Masquedós Rev. Ext. Univ.* 9:12. doi: 10.58313/masquedos.2024.v9.n11.266
- Mouchrek, N., Cullen, C., Ganino, A., Gliga, V., Kramer, P., Mahesh, R., et al. (2022). Investigating environmental values and psychological barriers to sustainable behaviors among college students. *Consilience* 26, 1–18. doi: 10.52214/consilience.vi26.10153
- Pato, C., and Delabrida, Z. N. (2019). Psicologia ambiental em contextos urbanos. Santa Catarina: UFSC/CFH/NUPPE.
- Pato, C., Sá, L. M., and Catalão, V. L. (2009). Mapeamento de tendências na produção acadêmica sobre educação ambiental. *Educ. Rev.* 25, 213–233. doi: 10.1590/S0102-46982009000300011
- Pato, C., and Tamayo, A. (2006). Valores, creencias ambientales y comportamiento ecológico de activismo. *Medio Ambiente y Comportamiento Hum. Rev. Int. Psicol. Ambiental* 7, 51–66.
- Portus, R., Aarnio-Linnanvuori, E., Dillon, B., Fahy, F., Gopinath, D., Mansikka-Aho, A., et al. (2024). Exploring environmental value action gap and education research: a semi-systematic literature review. *Environ. Educ. Res.* 30, 833–863. doi: 10.1080/13504622.2024.2314060
- Preston, C. C., and Colman, A. M. (2000). Optimal number of response categories in rating scales: reliability, validity, discriminating power, and respondent preferences. *Acta Psychol.* 104, 1–15. doi: 10.1016/S0001-6918(99)00050-5
- Quimby, C. C., and Angelique, H. (2011). Identifying barriers and catalysts to fostering pro-environmental behavior: opportunities and challenges for community psychology. *Am. J. Community Psychol.* 47, 388–396. doi: 10.1007/s10464-010-9389-7
- Rangel-S, M. L. (2008). Dengue: Educação, comunicação e mobilização na perspectiva do controle - propostas inovadoras. *Interface Comun.* 12, 433–441. doi: 10.1590/S1414-32832008000200018
- Reis, C. B., de Andrade, S. M. O., and da Cunha, R. V. (2013). Aliados do A. aegypti: fatores contribuintes para a ocorrência do dengue segundo as representações sociais dos profissionais das equipes de saúde da família. *Ciênc. Saúde Colet.* 18, 517–526. doi: 10.1590/S1413-81232013000200023
- Rosa, A. H. V., Granito, C. C. D., Abreu, A. D., Silva, D. D. N., de Oliveira, E. F. B., and Silva, S. D. B. (2020). A educação ambiental como instrumento na prevenção das arboviroses urbanas. *Revista da JOPIC* 3:34–39.
- Roy, S. K., and Bhattacharjee, S. (2021). Dengue virus: epidemiology, biology, and disease aetiology. *Can. J. Microbiol.* 67, 687–702. doi: 10.1139/cjm-2020-0572
- San Jose, A. L., and Nelson, K. E. (2017). Increasing Children's positive connection to, orientation toward, and knowledge of nature through nature camp experiences. *Int. J. Environ. Sci. Educ.* 12, 933–944.
- Schultz, P. W., and Kaiser, F. G. (2012). "Promoting pro-environmental behavior" in The Oxford handbook of environmental and conservation psychology. ed. S. D. Clayton (Oxford: Oxford University Press).
- Silva, F., Silva, J., Silva, D., Barbosa, R., and Cavalcante, L. (2018). Educação Ambiental no Processo de Sensibilização Sobre O Aedes Aegypti No Município de J. Sulistawati, S. (2024). Household waste management education for dengue fever prevention in Murtigading Bantul. *J. Pengabdian Masyarakat* 5, 46–52. doi: 10.32815/jpm.v5i1.1294
- Tam, K.-P., and Chan, H.-W. (2017). Environmental concern has a weaker association with pro-environmental behavior in some societies than others: a cross-cultural psychology perspective. *J. Environ. Psychol.* 53, 213–223. doi: 10.1016/j.jenvp.2017.09.001
- Teixeira, M. G., Costa, M. D. C. N., Barreto, F., and Barreto, M. L. (2009). Dengue: twenty-five years since reemergence in Brazil. *Cad. Saude Publica* 25, S7–S18. doi: 10.1590/S0102-311X2009001300002
- Tortosa-La Osa, S., Martín-Ruiz, E., Galán-Relaño, Á., and de Labry-Lima, A. O. (2022). Effectiveness of environmental interventions to reduce entomological indices of dengue, Zika, and chikungunya vector. *Acta Trop.* 233:106523. doi: 10.1016/j.actatropica.2022.106523
- Tucholska, K., Gulla, B., and Ziernicka-Wojtaszek, A. (2024). Climate change beliefs, emotions and pro-environmental behaviors among adults: the role of core personality traits and the time perspective. *PLoS One* 19:e0300246. doi: 10.1371/journal.pone.0300246
- Vu, D. M., Jungkind, D., and LaBeaud, A. D. (2017). Chikungunya Virus. *Clin. Lab. Med.* 37, 371–382. doi: 10.1016/j.clm.2017.01.008
- Wu, J., Wang, X., Ramkissoon, H., Wu, M.-Y., Guo, Y., and Morrison, A. M. (2023). Resource mobilization and power redistribution: the role of local governments in shaping residents' pro-environmental behavior in rural tourism destinations. *J. Travel Res.* 63, 1442–1458. doi: 10.1177/00472875231191983
- Xian, H. (2008). Lost in translation? Language, culture and the roles of translator in cross-cultural management research. *Q. Res. Org. Manage. Int. J.* 3, 231–245. doi: 10.1108/17465640810920304
- Yasmeen, B., Jamshaid, N., Khan, M. Z., Salman, M., and Ullah, R. (2015). Effectiveness of dengue fever prevention campaigns: a study of knowledge and practices in urban/semi-urban communities of Lahore. *Prof. Med. J.* 22, 571–576. doi: 10.29309/TPMJ/2015.22.05.1269
- Yuriev, A., Boiral, O., Francoeur, V., and Paillé, P. (2018). Overcoming the barriers to pro-environmental behaviors in the workplace: a systematic review. *J. Clean. Prod.* 182, 379–394. doi: 10.1016/j.jclepro.2018.02.041
- Zara, A. L. S. A., Santos, S. M., Fernandes-Oliveira, E. S., Carvalho, R. G., and Coelho, G. E. (2016). Estratégias de controle do *Aedes aegypti*: Uma revisão. *Epidemiol. Serv. Saúde* 25, 391–404. doi: 10.5123/S1679-49742016000200017



OPEN ACCESS

EDITED BY

Christian Andreas Klöckner,
NTNU, Norway

REVIEWED BY

Giuseppe Carrus,
Roma Tre University, Italy
Stefano Mastandrea,
Roma Tre University, Italy

*CORRESPONDENCE

Andreas Haga

✉ andreas.haga@hig.se

RECEIVED 14 September 2023

ACCEPTED 13 September 2024

PUBLISHED 01 November 2024

CITATION

Haga A (2024) Morally “loaded” labels in the built environment influence perceptions and social judgments. *Front. Psychol.* 15:1294220. doi: 10.3389/fpsyg.2024.1294220

COPYRIGHT

© 2024 Haga. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Morally “loaded” labels in the built environment influence perceptions and social judgments

Andreas Haga*

Department of Building Engineering, Energy Systems and Sustainability Science, Faculty of Engineering and Sustainable Development, University of Gävle, Gävle, Sweden

Products and artifacts with morally loaded labels (e.g., environmentally friendly) appear to influence people’s perceptions and behaviors. Previous studies have shown that desktop lamps labeled “environmentally friendly” can enhance perceived color discrimination and improve certain reading activities compared to a physically identical lamp labeled “conventional.” This effect may occur because people tend to align their behavior with moral principles. The present study explored the generalizability and robustness of this label effect by asking participants to make trait judgments of photographed faces. In an experimental design, participants evaluated photos illuminated by a desktop lamp that was either labeled environmentally friendly or not labeled at all. The results revealed that participants assigned more positive traits to individuals in the photographs when the lamp was labeled “environmentally friendly,” particularly those with high altruistic values. The pattern was reversed for participants with low altruistic values. Moreover, participants rated the light from the lamp labeled “environmentally friendly” as more comfortable and claimed that the light increased (perceived) visibility. In conclusion, the source of the light—whether from an environmentally friendly or conventional lamp—affects both the evaluation of the light itself and the judgments made about other individuals. This study explores theoretical explanations for these label effects and discusses their potential implications for pro-environmental interventions.

KEYWORDS

eco-label, moral, spillover, environment, social judgement, perception

Introduction

Impression formation is a subconscious process that occurs in our everyday lives, such as when a recruiter interviews a job applicant or when we need to assess whether someone is a friend or a foe (Willis and Todorov, 2006). Evaluating trustworthiness is an essential aspect of social interaction. We do not want to make mistakes when judging others, but whether we like it or not, our judgments are often biased. For instance, Williams and Bargh (2008) showed that holding a warm cup of coffee can bias people toward perceiving others as “warmer” compared to holding a cold cup. This suggests that seemingly irrelevant environmental cues, such as the warmth of a coffee cup, can trigger friendlier social judgments.

The empathy-altruism hypothesis posits that empathic emotions evoke genuine altruistic motivation (Batson and Shaw, 1991). A key research question addressed in the present study is whether “morally” loaded cues can similarly affect social judgments. More specifically, the hypothesis is that an environmentally friendly lamp label may prompt people to make more morally justifiable judgments of other people’s traits.

Some product labels are associated with social or environmental responsibility, which can lead morally conscious people to choose organic products over conventional ones and to be willing to pay more money for them (Krystallis and Chrysoschoidis, 2005; Sörqvist et al., 2013).

Therefore, “moral” labeling serves as a marketing tool to attract consumers who value social fairness or environmental altruism. In particular, eco-labeling can influence perceptions of products, making them appear superior to conventional alternatives, even when the products are identical (Annett et al., 2008; Haga, 2018; Sörqvist et al., 2015b). This preference bias for products labeled environmentally friendly is known as the *eco-label effect* (Sörqvist et al., 2013, 2015a,b; Haga, 2018).

The magnitude of this effect varies depending on individual differences in environment-related attitudes, reinforcing the hypothesis that the label’s influence stems from its appeals to certain individuals’ moral consciousness. Altruistic individuals tend to associate higher quality and value with “morally” labeled products and often idealize these options over “conventional alternatives” (Bamberg and Möser, 2007; Schwartz, 1977; Thøgersen, 1999).

People with an altruistic attitude are more likely to engage in pro-environmental behavior, express greater concern for the environment, and often perceive environmentally friendly products as more desirable in various ways compared to conventional ones (Holmgren et al., 2017; Sörqvist et al., 2013, 2015a,b; Yiridoe et al., 2005).

Several studies have shown that eco-labels influence perceptions of the products or objects to which they are attached. Interestingly, these labels can also affect perception and performance in ways that are seemingly unrelated to the labeling itself.

For example, people performed better on proofreading tasks when working at a desk lit by a lamp labeled “environmentally friendly” (Haga, 2018). A similar effect was observed in an experiment on color vision, where participants sorted colored cups more effectively when they believed the desk was illuminated by an “environmentally friendly” lamp, in contrast to when they thought that it was a conventional lamp, even though the two lamps were identical (Sörqvist et al., 2015a).

One possible explanation for this effect is that people perceive differences in production between eco-friendly and conventional products. Tasks such as color sorting and proofreading involve visuospatial processes that depend on good lighting conditions, and the label may enhance performance because people believe the “eco-labeled” lamp is superior to a conventional one.

The current study explores whether eco-labeling can influence subjective ratings (comfort and visibility) and the judgmental dimension that has, arguably, nothing to do with lighting quality, as opposed to proofreading and color vision, and provides an explanation for these effects. For this purpose, the participants were asked to make social judgments of photographed persons, viewed either in the light from a light source labeled “environmentally friendly” or from an unlabeled light source. If the label also has an effect in this context, where the behavior is unrelated to the lamp, it could be because of a strong spillover effect caused by people’s belief in the superiority of the lamp, especially for individuals with high environmental concerns.

Since the eco-label appears to enhance visuo-perceptual processes with behavioral consequences, it was hypothesized that participants would report that they could see the stimuli (i.e., photographed faces) more clearly and that they would rate the eco-labeled lamp as more comfortable when the lamp was labeled “environmentally friendly” (H1). Furthermore, behavioral effects of this type of labeling have achieved some generalizability, including performance on a color vision task and proofreading. In this study, the generalizability is tested even further to measure whether personal judgment can be affected by an eco-labeled lamp and if that effect can be predicted by people with high environmental concerns. The hypothesis (H2) is that people will be falsely influenced by the lamp label and, therefore, make more positive judgments of other people in a condition where the moral label is present. The third hypothesis (H3) is that this effect is mainly driven by people who are highly concerned about the environment. If hypothesis three is true, it would not just strengthen the generalizability of the already existing eco-label effect but also show that moral cues, such as labels, probably work like a catalyst to people prone to do morally good and create a spillover effect to domains outside the context at hand.

Methods

The experimental design was a mixed-participant one. The participants completed the task in both the control condition and the experimental condition. The order of conditions the participants were allocated to do first were counterbalanced. At the end of each task, all participants completed two questionnaires about environmental concerns and value orientation. These questionnaires were then collapsed and divided into a between-group variable.

Participants

A total of 44 Swedish students (65.3% women) (mean age = 25.04 years, $SD = 5.48$) were recruited to participate in the experiment. All participants were recruited at the University of Gävle and received a small honorarium for their participation. The recruiting process was conducted through an advertisement on a university webpage where students could sign up for the experiment.

Materials

Lamp

A classic incandescent (Osram Classic ECO Superstar) with 30 W input power was used in this study. The lamp had a D efficiency certification and an E14 screw base. The lamp and armature were designed as ordinary light bulbs and ordinary desktop armatures.

Statistical tools

Statistical Package for the Social Sciences (SPSS) was used for all analyses in the study.

Questionnaire on environmental concern and value orientations

To obtain a highly reliable measure of the three key attitudinal dimensions—biospheric, altruistic, and egoistic orientations—a scale for environmental concern (Stern and Dietz, 1994), along with a slightly different value orientation scale (De Groot and Steg, 2008; Stern et al., 1993), was used and collapsed into one scale. Both measure all three dimensions (biospheric, altruistic, and egoistic). The two altruistic dimensions, the two biospheric dimensions, and the two egoistic dimensions were averaged to obtain three more general indexes of altruistic orientation, biospheric orientation, and egoistic orientation, respectively. The reliability measures of the statistical analysis of Cronbach's α are reported in the Results Section and Table 1.

Design and procedure

A within-participants design was used with the lamp label as the independent variable. In one condition, the lamp was labeled “environmentally friendly,” and in the other, it was labeled “conventional” (although the lamp was identical in both conditions). The lamp label was communicated orally to the participants by the researcher, who told the participants whether the lamp was environmentally friendly or conventional, depending on the lamp's condition. Participants also received information regarding the lamp from a note attached to the lamp (white with black text), which stated that the lamp was environmentally friendly or conventional. Participants first completed the “judgments of lighting conditions and personality traits” task and then filled in the questionnaire on environmental concerns and value orientations. The order between the two lamp conditions in the “judgments of lighting conditions and personality traits” task was counterbalanced between participants, which means all facial pictures were included in both lamp conditions.

Participants were presented with a paper-and-pencil questionnaire and a set of facial photographs. Their task consisted of three phases. In the first phase, they rated how well they could see the picture in front of them (hereafter called “visibility”) on a scale ranging from 1 (not at all well) to 11 (very well). In the next phase, they rated eight personality traits of the photographed person (only one picture from the set). The personality ratings were made on a scale from 1 to 6 and with dichotomous endpoints (i.e., responsible vs. irresponsible; selfish vs. unselfish; not environmentally friendly vs. environmentally friendly; cold vs. warm; dishonest vs. honest; wasteful vs. economic; ruthless vs. charitable; uninterested vs. clever) (Asch, 1946). In the final phase, participants rated how comfortable it had been to work under the lamp's illumination on a scale ranging from 1 (not at all comfortable) to 11 (very comfortable). The three phases were repeated 16 times. Half (eight pictures/cycles) was conducted in one lamp condition, and the other half (eight pictures/cycles) was conducted in the other lamp condition.

An aggregated score for personality judgments was calculated across eight judgmental dimensions and eight photographed individuals in each lamp-label condition (a total of 64 personality judgments per condition). Some of the judgmental dimensions were inverted to ensure that higher values consistently represented a more positive evaluation (e.g., a high level of responsibility) of the photographed individuals' personalities.

The personality judgments were then averaged into a mean score for each participant in both lamp-label conditions.

Results

Cronbach's α

This is a reliable measure for the two scales together in all three dimensions where the following results were obtained: egoistic dimension, $M = 4.55$, $SD = 1.53$, Cronbach's $\alpha = 0.87$, biospheric dimension, $M = 5.69$, $SD = 1.29$, Cronbach's $\alpha = 0.86$, and altruistic dimensions, $M = 6.10$, $SD = 1.04$, Cronbach's $\alpha = 0.79$ (Table 1). The three-dimensional indexes were then adjusted (as proposed by Haugh, 1976) by subtracting the grand mean across all three dimensions from the mean of each environmental concern dimension (egoistic, altruistic, and biospheric). The relative scores that result from this adjustment procedure indicate how much higher (or lower) the score is compared with the other two dimensions. For example, a high score on the biospheric dimension indicates that the person who obtained that score had a relatively high score compared to the scores on the other two dimensions. Thus, an absolute altruistic environmental concern score of 6 on a scale of 1–7 can still be low when the indexes are adjusted if that person also obtains a 6 on the other two dimensions.

Mixed analysis of variance

These conclusions were supported by a 2 (Altruistic environmental concern/value orientation: high vs. low) $\times$ 2 (Label: eco-friendly vs. conventional) mixed analysis of variance with comfort as the dependent variable. The analysis revealed no significant interaction between the two factors $F_{(1,42)} = 0.02$, $p = 0.903$, $\eta_p^2 = 0.00$, but a main effect of lamp label was found, $F_{(1,42)} = 11.64$, $p = 0.001$, $\eta_p^2 = 0.22$.

Difference scores were calculated for judgments of comfort ($M_{\text{diff}} = 0.95$, $SD = 1.82$), and the results showed that participants rated the light created by the light from the lamp in the “environmentally friendly” lamp condition as better than that in the “conventional” label condition. The same analysis was conducted for visibility. The analysis revealed no significant interaction between the two factors $F_{(1,42)} = 0.54$, $p = 0.468$, $\eta_p^2 = 0.01$, but a main effect of lamp label was found, $F_{(1,42)} = 7.71$, $p = 0.008$, $\eta_p^2 = 0.16$. The difference scores were calculated for judgments of visibility ($M_{\text{diff}} = 0.52$, $SD = 1.23$), and the results showed that participants rated the visibility created by the light from the lamp in the “environmentally friendly” lamp label condition as better than the light in the “conventional” lamp label condition.

However, the eco-label effect (i.e., the difference between the two lamp-label conditions) on personality judgments varied with individual differences in altruistic environmental concern/value orientation (Table 2). Most notably, the positive correlation

TABLE 1 Cronbach's alpha for questions measuring environmental concern and value orientation.

Cronbach's alpha	
Questions environmental concern	
How concerned are you that today's environmental problems will affect ...?	
Egoistic	$\alpha = 0.91$
1. My self	
2. My lifestyle	
3. My health	
4. My future	
Altruistic	$\alpha = 0.79$
5. All human beings	
6. People close to me	
7. Future generations	
8. My children	
Biospheric	$\alpha = 0.87$
9. All living things	
10. Plants	
11. Animals	
12. Life at sea	
Questions value orientation scale	
How important is each of this for you?	
Egoistic	$\alpha = 0.78$
1. Social power	
2. Wealth	
3. Authority	
4. Influential	
5. Ambitious	
Altruistic	$\alpha = 0.52$
6. Equality	
7. A world at peace	
8. Social justice	
9. Helpful	
Biospheric	$\alpha = 0.80$
10. Preventing pollution	
11. Respecting the earth	
12. Unity with nature	
13. Protecting the environment	
Environmental concern and value orientation collapsed	
1. Egoistic	$\alpha = 0.87$
2. Altruistic	$\alpha = 0.79$
3. Biospheric	$\alpha = 0.86$

$N = 44$.

TABLE 2 Intercorrelations amongst the variables in Experiment 2 ($N = 44$).

Variable	1.	2.	3.	4.	5.
1. Egoistic (adjusted)	-				
2. Altruistic (adjusted)	-0.42**	-			
3. Biospheric (adjusted)	-0.83**	-0.15	-		
4. Differences in personality judgements	-0.20	0.47**	0.08	-	
5. Differences in comfort	-0.10	0.01	0.12	-0.10	-
6. Differences in visibility	-0.11	0.08	0.10	-0.03	0.76**

The table shows correlations between three indexes of environmental concern/value orientations and the difference scores between the “environmentally friendly” lamp label condition and the “conventional” lamp label condition across three dependent variables (comfort ratings, visibility, and personality judgments). ** $p < 0.001$.

between personal judgment and altruistic environmental concern/value orientation indicated that the eco-label effect increases with individual differences in altruism.

To illustrate the interaction between the lamp label condition and environmental concern/value orientation, the participants were divided into two groups based on a median split (high altruistic environmental concern/value orientation, $M = 1.93$, $SD = 0.68$, vs. low altruistic environmental concern/value orientation; $M = 0.82$, $SD = 0.44$). Figure 1 shows that participants with a high altruistic environmental concern/value orientation evaluated the photographed persons more positively when the lamp was labeled “environmentally friendly,” compared to when the lamp was labeled “conventional,” whereas participants with a low altruistic environmental concern/value orientation evaluated the photographed people less favorably when the lamp was labeled “environmentally friendly” compared to when the lamp was labeled “conventional.” These conclusions were supported by a 2 (altruistic environmental concern/value orientation: high vs. low) $\times$ 2 (Label: eco-friendly vs. conventional) mixed analysis of variance with personality judgments as the dependent variable. The analysis revealed a significant interaction between the two factors, $F_{(1,42)} = 5.72$, $p = 0.021$, $\eta_p^2 = 0.19$, while no main effect was significant, $F_{(1,42)} = 0.13$, $p = 0.721$, $\eta_p^2 = 0.003$.

The follow-up t -test analysis showed that the interaction was driven by differences in altruism levels, with highly altruistic individuals giving more positive judgments in the eco-friendly condition $t_{(42)} = 2.12$, $p = 0.046$, indicating that the eco-label effect was stronger for participants with a higher altruistic environmental concern/value orientation (Figure 1).

Discussion

Participants assigned more favorable ratings of the light from the light source when it was labeled “environmentally friendly” compared to the lamp labeled conventional. Moreover, the results also showed that the effect of eco-labeling generalizes to subjective evaluations of target objects lit up by the lamp: the participants assigned what are, arguably, more positive personality traits to the photographed persons when the photos were viewed in the spotlight from a lamp with an “environmentally friendly” label.

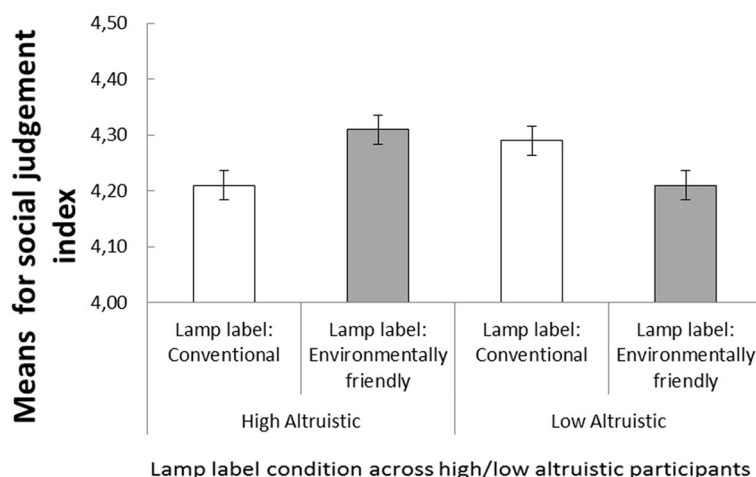


FIGURE 1

Participants with high altruistic environmental concern/value orientation assigned more positive personality traits to photographed people when the photographs were enlightened by a lamp that was labeled “environmentally friendly” than when the lamp was labeled “conventional.” The opposite was found for participants with low altruistic environmental concern/value orientation. Error bars represent the standard error of the means.

However, this was only true for participants with high altruistic environmental concerns and value orientation.

A likely explanation for the eco-label effect is the strong spillover effect. When this effect extends from pro-environmentally to more pro-social behavior, it suggests that the behavior is driven by deeper, more fundamental predispositions than only favorable perceptions of a product (e.g., a lamp). A more specific explanation of this spillover effect is the halo effect (Thorndike, 1920), where overall impressions and feelings about a person or a brand influence our perceptions of their other qualities. For example, if we believe an eco-friendly labeled lamp is better for the environment, we may also assume it provides better light.

Additionally, the eco-label effect can be understood as a perception bias—people tend to experience and behave according to their expectations (Haga et al., 2016). When exposed to something that aligns with their moral values, individuals act in ways that confirm those values, effectively avoiding inner conflicts (Stern et al., 1985). In this case, altruistic individuals favor the eco-friendly lamp, while those with opposing values may prefer the conventional lamp.

As previously mentioned, the eco-label effect has been demonstrated across a wide range of products and domains, from taste perceptions of food items such as bananas, raisins, and grapes to artifacts such as lamps (Haga, 2018) and even buildings (Holmgren and Sörqvist, 2018). The effect has also been observed in fundamental behaviors like color vision and tasks involving cognitive activities, such as proofreading and language processing. In this study, the eco-label effect was found to influence social judgments, which involve memory and cognitive reasoning. Moreover, the effect appears stronger among individuals who are environmentally conscious and possess altruistic values.

One way to explain this phenomenon is by identifying a single mechanism that underpins all these varied behaviors and perceptions. Alternatively, it may be that multiple mechanisms are at play, depending on the context. For example, when explaining the effect on taste, beliefs about the production

process could be a plausible explanation. For color vision and proofreading, the alignment between personal values and external product information (e.g., an eco-label) might encourage deeper engagement with the task. However, these explanations do not fully account for the impact on social judgments.

Why do altruistic individuals rate others more positively when exposed to an eco-label compared to a conventional one? It may be that eco-labels serve as cues that trigger moral responsibility in those with altruistic values, leading to more favorable judgments of others. Research has shown that people rate photographs of others more positively when viewed in an aesthetically pleasing room, judging the person in the photograph as more attractive compared to when the same photographs are viewed in an unattractive room (Maslow and Mintz, 1956). This effect is similar to the one observed in the current study, suggesting that the environment or environmental cues, such as the Thorndike halo effect, can induce positive feelings that extend to other judgments.

It can be argued that pro-social and pro-environmental behaviors may both stem from similar moral obligations (Bamberg and Möser, 2007), supporting the decision to collapse the two scales of value orientation and environmental concern. Several primary studies provide evidence that moral norms contribute to explaining pro-environmental behaviors such as energy conservation (Black et al., 1985), recycling (Guagnano et al., 1995), traveling alternatives (Hunecke et al., 2001), and pro-environmental consumption (Thøgersen, 1999). As reported above, significant studies have found a mean correlation of $r = 0.33$ between a feeling of moral obligation and pro-environmental behavior (Hines et al., 1987). Moreover, the internal attribution of a harmful behavior often triggers emotional guilt reactions (Weiner, 2000). To avoid a mismatch between one's own behavior and social norms, people behave according to their moral obligations (Joireman, 2004).

Comfort and visibility were rated significantly higher in the eco-label condition, while personal trait ratings did not show a significant difference. This may be due to the fundamental differences between perception (comfort and visibility) and

behavioral judgments. Moreover, it is probably easier to imagine that increased features such as visibility and comfort are related to lamp type, even for participants with low altruistic values. For more abstract effects such as social judgment, higher altruistic values are necessary to generate motivation for the eco-label effect. Therefore, the likelihood of a spillover effect is greater (Thøgersen and Ölander, 2003).

Implications and further research

Further research should investigate why eco-labeled products do not appeal to some people. In this study, some valuable insights were found about the eco-labeled effect, which builds on previous research showing that people concerned about the environment are generally more sensitive to the eco-label effect. However, these individuals are not the target group from an applied perspective, as they already think about environmental issues and behave accordingly. The issue is thus that people are low in environmental concern. Research should also explore why some people are not concerned about the environment, find ways to influence such people to behave in favor of the planet, and help deal with climate issues. To make this implication possible, it is necessary to target the underlying mechanisms and barriers to these decisions.

This study did not aim to find solutions to combat climate change but rather to explore the generalizability of the eco-label effect and gain a deeper understanding of human behavior in general. However, an implication for climate change emerging from this study is the potential to design interventions that might induce negative spillover effects, as suggested by the results. Eco-labeling, while useful, may have flaws that could be counterproductive for climate change mitigation efforts and should thus be carefully investigated.

Moreover, the majority of the pro-environmental interventions in the current times, such as promoting collective transport at bus stations and eco-labeling, often mistakenly target people who already care about the environment, resulting in misdirected efforts. For example, people using collective transport at bus stations are already engaging in environmentally friendly behavior, so targeting them leads to poorly allocated resources. Instead, interventions should focus on people with low environmental concerns and be carefully designed to engage them without causing negative spillover or alienating them.

This issue extends to other climate change challenges. For instance, interventions in areas threatened by rising sea levels should be tailored to address those specific risks, while inland interventions should focus on relevant environmental concerns. Future research should prioritize strategies that target individuals

who struggle to engage in pro-environmental behaviors. According to Truelove et al. (2014), if promoting pro-environmental behavior leads to positive spillover effects, these investments can offer significant benefits.

Data availability statement

The data that support the findings of this study are available from the University of Gävle but restrictions apply to the availability of these data and so are not publicly available. Data are however available from the authors upon request and with permission of University of Gävle. A request can be made at <https://doi.org/10.5878/0q8f-ya14>.

Ethics statement

The studies involving humans were approved by the Research Ethical Review Board at Uppsala University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AH: Writing – original draft.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Annett, L. E., Muralidharan, V., Boxall, P. C., Cash, S. B., and Wismer, W. V. (2008). Influence of health and environmental information on hedonic evaluation of organic and conventional bread. *J. Food Sci.* 73, H50–H57. doi: 10.1111/j.1750-3841.2008.00723.x
- Asch, S. E. (1946). Forming impressions of personality. *J. Abnorm. Soc. Psychol.* 41, 258. doi: 10.1037/h0055756
- Bamberg, S., and Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: a new meta-analysis of psycho-social determinants of

- pro-environmental behaviour. *J. Environ. Psychol.* 27, 14–25. doi: 10.1016/j.jenvp.2006.12.002
- Batson, C. D., and Shaw, L. L. (1991). Evidence for altruism: toward a pluralism of prosocial motives. *Psychol. Inq.* 2, 107–122. doi: 10.1207/s15327965pli0202_1
- Black, J. S., Stern, P. C., and Elworth, J. T. (1985). Personal and contextual influences on household energy adaptations. *J. Appl. Psychol.* 70:3. doi: 10.1037/0021-9010.70.1.3
- De Groot, J. I. M., and Steg, L. (2008). Value orientations to explain beliefs related to environmental significant behavior: how to measure egoistic, altruistic, and biospheric value orientations. *Environ. Behav.* 40, 330–354. doi: 10.1177/0013916506297831
- Guagnano, G. A., Stern, P. C., and Dietz, T. (1995). Influences on attitude-behavior relationships: a natural experiment with curbside recycling. *Environ. Behav.* 27, 699–718. doi: 10.1177/0013916595275005
- Haga, A. (2018). Eco-label effects in the built environment: does labeling a light source environmentally friendly influence performance and judgment? *SAGE Open* 2:2158244018766977. doi: 10.1177/2158244018766977
- Haga, A., Halin, N., Holmgren, M., and Sörqvist, P. (2016). Psychological restoration can depend on stimulus-source attribution: a challenge for the evolutionary account? *Front. Psychol.* 7:1831. doi: 10.3389/fpsyg.2016.01831
- Haugh, L. D. (1976). Checking the independence of two covariance-stationary time series: a univariate residual cross-correlation approach. *J. Am. Stat. Assoc.* 71, 378–385.
- Hines, J. M., Hungerford, H. R., and Tomera, A. N. (1987). Analysis and synthesis of research on responsible environmental behavior: a meta-analysis. *J. Environ. Educ.* 18, 1–8. doi: 10.1080/00958964.1987.9943482
- Holmgren, M., Kabanshi, A., and Sörqvist, P. (2017). Occupant perception of “green” buildings: distinguishing physical and psychological factors. *Build. Environ.* 114, 140–147. doi: 10.1016/j.buildenv.2016.12.017
- Holmgren, M., and Sörqvist, P. (2018). Are mental biases responsible for the perceived comfort advantage in “green” buildings? *Buildings* 8:20. doi: 10.3390/buildings8020020
- Hunecke, M., Blöbaum, A., Matthies, E., and Höger, R. (2001). Responsibility and environment: ecological norm orientation and external factors in the domain of travel mode choice behavior. *Environ. Behav.* 33, 830–852. doi: 10.1177/00139160121973269
- Joireman, J. (2004). Empathy and the self-absorption paradox II: self-rumination and self-reflection as mediators between shame, guilt, and empathy. *Self Ident.* 3, 225–238. doi: 10.1080/13576500440000038
- Krystallis, A., and Chrysoschoidis, G. (2005). Consumers’ willingness to pay for organic food: factors that affect it and variation per organic product type. *Br. Food J.* 107, 320–343. doi: 10.1108/00070700510596901
- Maslow, A. H., and Mintz, N. L. (1956). Effects of esthetic surroundings: I. Initial effects of three esthetic conditions upon perceiving “energy” and “well-being” in faces. *J. Psychol.* 41, 247–254. doi: 10.1080/00223980.1956.9713000
- Schwartz, S. H. (1977). “Normative influences on altruism,” in *Advances in experimental social psychology* (Academic Press), 221–279. doi: 10.1016/S0065-2601(08)60358-5
- Sörqvist, P., Haga, A., Holmgren, M., and Hansla, A. (2015a). An eco-label effect in the built environment: performance and comfort effects of labeling a light source environmentally friendly. *J. Environ. Psychol.* 42, 123–127. doi: 10.1016/j.jenvp.2015.03.004
- Sörqvist, P., Haga, A., Langeborg, L., Holmgren, M., Wallinder, M., Nösl, A., et al. (2015b). The green halo: mechanisms and limits of the eco-label effect. *Food Qual. Prefer.* 43, 1–9. doi: 10.1016/j.foodqual.2015.02.001
- Sörqvist, P., Hedblom, D., Holmgren, M., Haga, A., Langeborg, L., Nösl, A., et al. (2013). Who needs cream and sugar when there is eco-labeling? Taste and willingness to pay for “eco-friendly” coffee. *PLoS ONE* 8:e80719. doi: 10.1371/journal.pone.0080719
- Stern, P. C., and Dietz, T. (1994). The value basis of environmental concern. *J. Soc. Issues* 50, 65–84. doi: 10.1111/j.1540-4560.1994.tb02420.x
- Stern, P. C., Dietz, T., and Black, J. S. (1985). Support for environmental protection: the role of moral norms. *Popul. Environ.* 8, 204–222. doi: 10.1007/BF01263074
- Stern, P. C., Dietz, T., and Kalof, L. (1993). Value orientations, gender, and environmental concern. *Environ. Behav.* 25, 322–348. doi: 10.1177/0013916593255002
- Thøgersen, J. (1999). The ethical consumer. Moral norms and packaging choice. *J. Consumer Policy* 22, 439–460. doi: 10.1023/A:1006225711603
- Thøgersen, J., and Ölander, F. (2003). Spillover of environmentally friendly consumer behavior. *J. Environ. Psychol.* 23, 225–236. doi: 10.1016/S0272-4944(03)00018-5
- Thorndike, E. L. (1920). A constant error in psychological ratings. *J. Appl. Psychol.* 4, 25–29. doi: 10.1037/h0071663
- Truelove, H. B., Carrico, A. R., Weber, E. U., Raimi, K. T., and Vandenbergh, M. P. (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. *Global Environ. Change* 29, 127–138. doi: 10.1016/j.gloenvcha.2014.09.004
- Weiner, B. (2000). Attributional thoughts about consumer behavior. *J. Consumer Res.* 27, 382–387. doi: 10.1086/317592
- Williams, L. E., and Bargh, J. A. (2008). Experiencing physical warmth promotes interpersonal warmth. *Science* 322, 606–607. doi: 10.1126/science.1162548
- Willis, J., and Todorov, A. (2006). First impressions making up your mind after a 100-ms exposure to a face. *Psychol. Sci.* 17, 592–598. doi: 10.1111/j.1467-9280.2006.01750.x
- Yiridoe, E. K., Bonti-Ankomah, S., and Martin, R. C. (2005). Comparison of consumer perceptions and preference toward organic versus conventionally produced foods: a review and update of the literature. *Renew. Agric. Food Syst.* 20, 193–205. doi: 10.1079/RAF2005113



OPEN ACCESS

EDITED BY

Giuseppe Carrus,
Roma Tre University, Italy

REVIEWED BY

Sara Manca,
Università di Cagliari, Italy
Lorenza Tiberio,
Roma Tre University, Italy

*CORRESPONDENCE

Cristina Gómez-Román
✉ cristina.gomez@usc.es

RECEIVED 07 June 2024

ACCEPTED 22 October 2024

PUBLISHED 05 November 2024

CITATION

Vila-Tojo S, Gómez-Román C and Sabucedo J-M (2024) The role of information and participation in overcoming users' initial reluctance: a case study of a decentralized wastewater treatment plant.
Front. Psychol. 15:1445320.
doi: 10.3389/fpsyg.2024.1445320

COPYRIGHT

© 2024 Vila-Tojo, Gómez-Román and Sabucedo. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

The role of information and participation in overcoming users' initial reluctance: a case study of a decentralized wastewater treatment plant

Sergio Vila-Tojo, Cristina Gómez-Román* and Jose-Manuel Sabucedo

CRETUS, Department of Social Psychology, Basic Psychology and Methodology, Faculty of Psychology, University of Santiago de Compostela, Santiago de Compostela, Spain

Decentralized wastewater treatment systems are a potential solution to the water crisis. However, in addition to advanced technology, successful implementation of these systems requires broad public willingness to use them. This paper presents the results of a three-phase psychosocial intervention with the users of a business building where a decentralized wastewater treatment plant was installed. The intervention, motivated by complaints from users due to their lack of knowledge about the existence of the plant, aimed at understanding and improving users' perceptions of the building's decentralized system. In the first phase, we conducted a focus group with a sample of workers ($n = 6$) to understand their knowledge and perception of the building's decentralized wastewater treatment system. Once the main obstacles and facilitators were identified, we designed a second phase where a group of employees ($n = 46$) were exposed to environmental priming to improve attitudes toward the decentralized plant installed in the building. Finally, in the third phase, a bidirectional informative session was proposed, conducted by experts, to another group of workers ($n = 25$). Findings suggest that implementing specific psychosocial strategies, such as promoting environmental awareness and providing informative sessions, along with incorporating potential users throughout the process, contributes to better acceptance of the decentralized wastewater treatment plant. This work presents a real case in a pilot plant that can serve as a guide for addressing psychosocial resistance in similar projects.

KEYWORDS

acceptance, decentralized wastewater treatment systems, psychosocial intervention, social perception, attitudes, priming

1 Introduction

The installation of decentralized plants is proposed as a solution to the problem of water scarcity and water quality worldwide (Lens et al., 2005; Roefs et al., 2017). This type of system follows a circular economy principle for water reuse. It starts separating wastewater from the source, which allows the application of specific treatments that purify the water. Subsequently, the resulting water is reused for non-potable and potable purposes, depending on the treatment administered. However, despite the advantages and guarantees of this type of systems, people can be reluctant to use it, especially if they perceived any inconveniences in its installation or functioning (Brouwer et al., 2015; Ellis et al., 2021).

An example of this is the Porto do Molle Business Center in Nigrán, Galicia, Spain (case study), which accommodates 200–300 employees in coworking spaces for start-up companies. This building was, at that time, one of the few in Spain to operate with a decentralized system and, therefore, not rely on an external wastewater treatment plant for wastewater treatment. The building's decentralized plant separates grey water from black water, which makes it possible, on the one hand, to reuse the water from the sinks for flushing the toilets. On the other hand, through anaerobic treatment of the sewage, two by-products are obtained: (a) nutrients for fertilizer production (Bisschops et al., 2019) and (b) biogas as an energy source (Hao et al., 2019).

Despite its innovative design and sustainable contribution to the building, most workers, especially new hires, were unaware of its existence. These workers became aware of the decentralized system following a technical problem that resulted in the emission of unpleasant odors. Although the problem did not compromise health, it caused significant discomfort among the workers who expressed concerns about the decentralized plant. Those negative perceptions toward the plant would have been caused by the high uncertainty associated with the lack of understanding of the technology. In this context, epistemic demand is activated, that is the need to seek information to resolve uncertainty (Sabucedo et al., 2020).

In order to reduce the uncertainty associated with the incident, we propose an intervention based on three theoretical axes: (a) knowledge, (b) trust and (c) participation. Following the foundations of the knowledge deficit model, providing information with the aim of increasing knowledge about the decentralized plant can contribute to reduce uncertainty and increasing positive attitudes (Bauer et al., 2007; Gustafson and Rice, 2016). However, considering that discomfort about the plant installation had already been expressed, simply increasing knowledge might not be sufficient (Schultz, 2002). In this sense, it is necessary to consider who and how the information is presented. The selection of trustworthy agents for the audience and the way in which the information is framed is a fundamental aspect for the message to be persuasive (Meyer, 1988). Moreover, it is necessary to actively involve workers (Wibeck, 2014) by facilitating a space that would allow them to openly express their concerns and generate a trust environment for greater permeability of the information provided.

On this basis, the intervention consisted of three sequential phases. In the first phase, a focus group explored workers' knowledge and perceptions about the building's decentralized wastewater treatment system. Based on the results of this initial approach, a second phase was carried out with another group of workers, who participated in an experiment using environmental priming to improve attitudes toward the decentralized treatment system installed in the building. Finally, we evaluated how a bidirectional informative session led by experts affected users' perceptions of the decentralized plant.

2 Phase 1. Approaching workers' perceptions of the plant

The decentralized plant at the business center is not the only case facing public resistance. In other jurisdictions, reuse projects have even failed due to this social rejection (Hurlimann and Dolnicar, 2010;

Brouwer et al., 2015). For this reason, the starting point of the intervention in this building was to explore the extent to which psychosocial facilitators and barriers identified in other contexts were also present in this specific context (Gómez-Román et al., 2020; Hurlimann and Dolnicar, 2010; Mankad and Tapsuwan, 2011).

An unpleasant appearance or smell in the building, as in this case, can influence the formation of health risk perceptions (Etale et al., 2020; Fielding et al., 2018) and trigger negative emotional reactions related to fear or disgust that hinder acceptance, such as the well-known “yuck factor” (Po et al., 2003). This may lead people to reject decentralized plants if they perceive the system or the quality of the treated water as threatening their safety or that of their families (Fielding et al., 2018).

Beyond this relevant issue, other psychosocial factors can lead people to position themselves in favor or against these decentralized plants. Not being aware of a water scarcity problem may result in the perception that the decentralized plant is unnecessary, and thus reduce the level of acceptance (Fielding et al., 2018). Even recognizing the problem and the appropriateness of the plant to tackle it, people also consider other costs and benefits associated with decentralized plants before accepting it. The perception of high installation and maintenance costs could lead to low acceptance (Mankad, 2012); whereas the perception of high environmental and economic benefits would increase acceptance (Domènech and Saurí, 2010; Koetse, 2005).

It should be noted that the formation of perceptions and emotions is largely grounded in our social exchanges (Jaspal and Breakwell, 2014). When the proposal to reuse water comes from an in-group member, acceptance increases as there is greater credibility and trust between the actors (Ross et al., 2014; Schultz and Fielding, 2014). Moreover, if their use is perceived as a common practice (descriptive social norm) and approved (injunctive norm) by society, individuals are more likely to be inclined to adopt and endorse these systems (Lamichhane and Babcock, 2013; Liu et al., 2022).

In summary, different factors have been identified as influencing the acceptance of decentralized wastewater treatment systems. To find out whether these barriers and facilitating factors are also present in the building users, we designed a focus group with several workers to find out their reactions to the installed plant in the building.

2.1 Materials and methods

2.1.1 Participants and procedure

The focus group included six building workers with different profiles: management, building, maintenance and housekeeping, cleaning, and building user companies. The group was composed of three men and three women, with ages ranging from 25 to 60 years. This variability allows us to obtain different perspectives and identify overlaps between the different profiles, which is valuable evidence contributing to the results' validity (Bowen, 2008; Watts et al., 2017).

Our decision to limit the focus group to a maximum of six participants was guided by the recommendations of Krueger and Casey (1994) and Morgan (1997). This approach was chosen to maintain the quality of the discussion, as larger groups can lead to increased moderator intervention and participant inhibition, thereby compromising the richness of the data.

The focus group was conducted in a room within the building. Participants were invited to take part in a study focusing on the

business center. Prior to starting, they were provided with a clear understanding of the study's objective, privacy policy, and data protection measures. To ensure their full understanding and agreement, participants were asked to sign an informed consent form, thereby confirming their voluntary participation in the study.

An expert moderator facilitated the focus group session, which lasted approximately an hour and a half. The session followed a standardized script to gather accurate information (see [Supplementary material](#)). To start the conversation, the moderator began by asking about environmental concerns in the area. Then, questions were asked about participants' knowledge of the water problem in the region and the building's decentralized wastewater treatment technology. Participants were then asked to identify the potential advantages and disadvantages they believed could result from implementing this system and to evaluate their satisfaction with the decentralized wastewater treatment plant installed in the building.

2.1.2 Data analysis

This work constitutes primary qualitative research, for which a thematic analysis approach was adopted ([Thomas and Harden, 2008](#); [Cruzes and Dyba, 2011](#)) to identify, analyze, and report patterns (themes) in the data, coded segment by segment ([Cruzes and Dyba, 2011](#)). This means that each part of the text is individually examined to identify significant elements, which are then assigned codes that allow for systematic categorization and organization of the information. Through this coding process, it is possible to detect relevant patterns and themes throughout the discussion ([Cruzes and Dyba, 2011](#)). The thematic analysis of the focus group was conducted using Atlas.ti 9 software. The data analysis method is broken down into three phases: (1) coding, (2) enhancing coding reliability, and (3) synthesis. The process of each phase is detailed in [Supplementary material](#).

2.2 Results and discussion of phase 1

Participants expressed psychosocial barriers similar to those observed in other contexts of acceptance of decentralized wastewater treatment systems ([Mankad, 2012](#); [Singh et al., 2014](#); [Simha and Ganesapillai, 2017](#)). Specifically, the qualitative analysis of the data resulted in the proposal of three central categories: (a) knowledge, (b) advantages, and (c) disadvantages (see [Figure 1](#)).

The "knowledge" category highlights two points of interest. On one hand, users do not consider there to be a water quantity or quality problem in the area. The lack of perception of a water problem that requires a solution leads users to view changing existing systems as unnecessary, resulting in greater resistance to decentralized plants ([Gómez-Román et al., 2020](#); [Nancarrow et al., 2010](#)). On the other hand, participants referred to know the existence of the technology used in the decentralized plant of the building. However, since the plant became known due to the initial technical incident mentioned earlier, awareness of its existence could be related to high uncertainty ([Yates and Stone, 1992](#)).

Users articulated more disadvantages than advantages regarding the decentralized plant, revealing their discomfort with the technology, similar to what was found in other projects ([Domènech and Saurí, 2010](#)). They voiced concerns about the maintenance demands of the plant ([Mankad, 2012](#); [Mankad et al., 2010](#)); but the primary drawback

was the odors ([Haddad et al., 2018](#)), one of the consequences of the technical incident in the building's plant. The emotional reaction of disgust associated with odors functions as a protective mechanism, prompting individuals to oppose the stimulus that is perceived as a pollutant, thereby increasing the rejection of the plant ([Rozin et al., 2015](#)).

The focus group also highlighted "social disadvantages." Participants emphasized the general population's (and building users) lack of preparation to undertake the necessary changes to implement these new technological systems ([Moglia et al., 2011](#); [Rygaard et al., 2014](#)).

Despite the verbalized disadvantages, users also pointed out arguments in favor of the decentralized plant, mainly highlighting its added value compared to centralized plants: reduced operating costs and simplicity of system implementation ([Ho and Anda, 2006](#)). They also acknowledged the positive environmental impact the system can have. This suggests that the pro-environmental message has permeated the moral schemas of the population ([Lewis et al., 2019](#); [Poortinga et al., 2019](#)). Despite the perceived environmental advantages, users indicated that social agreements are necessary before implementing decentralized systems. In this sense, they consider it crucial to emphasize the environmental contribution of the plant so that users feel part of the solution and express greater social support for the decentralized system ([Gómez-Román et al., 2020](#); [Mankad et al., 2010](#)).

Given the existence of negative perceptions among users, partly attributable to the uncertainty produced by how they learned about the system (technical incident), Phase 2 proposes an intervention in which information is provided to improve attitudes toward the decentralized plant.

3 Phase 2. Priming environmental concern to improve acceptance

Providing specific information about the technology can help eliminate doubts and reservations that users may have about the plant. However, the mere provision of data may be insufficient. It is necessary to consider how that information is presented and integrated into the "common sense" or pre-existing social frameworks ([Gramsci, 1971](#)).

The results from the focus group indicate that users perceive one of the plant's main strengths to be its positive environmental impact. In this sense, the activation and accessibility of environmental concerns can positively influence attitudes, emotions, and behaviors toward decentralized plants, thereby increasing their acceptance ([Gómez-Román et al., 2021](#)). This accessibility can be achieved through priming. By exposing users to information about well-known environmental problems, these concerns become more accessible, thereby affecting subsequent attitudes and decisions regarding the decentralized plant ([Jonas and Sassenberg, 2006](#); [Custers and Aarts, 2010](#); [Scheufele and Tewksbury, 2007](#)).

Our research not only focuses on activating environmental concerns through priming but also considers the impact of the unilaterality/bilaterality of the arguments presented about decentralized plants. Unilateral arguments highlight the advantages, while bilateral arguments provide a balanced view by including both positive and negative aspects of the technology.

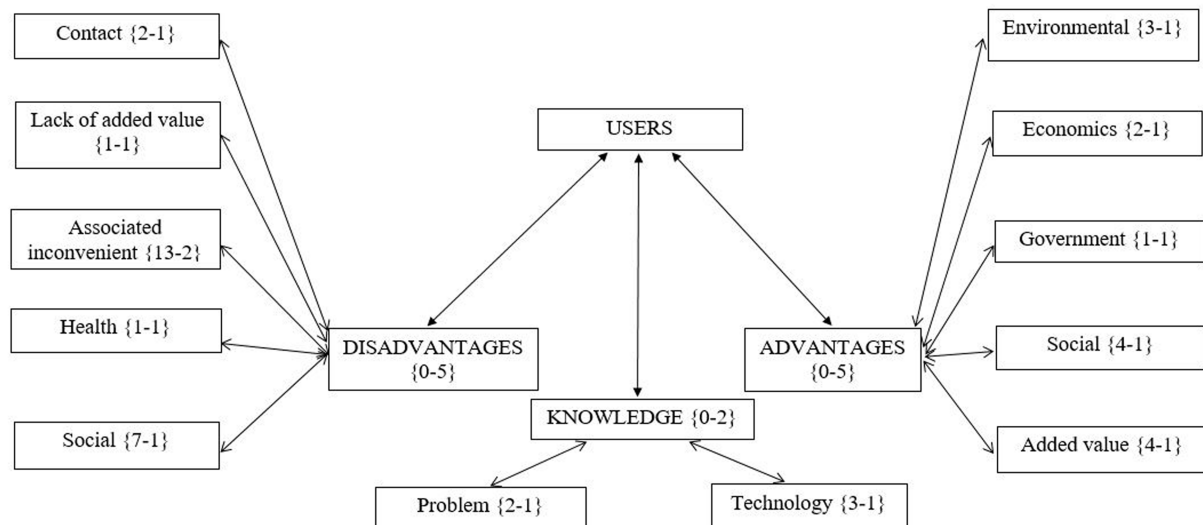


FIGURE 1
Qualitative analysis of the focus group at the business center.

The evidence on which type of argument—unilateral or bilateral—is more effective remains inconclusive, as several factors may influence its impact (Allen, 1991). Unilateral messages, which present only the positive aspects of an argument, tend to be more direct and effective, especially when the audience is unfamiliar with an issue. In contrast, bilateral messages (i.e., including advantages and acknowledging disadvantages) may reinforce the credibility of the source and increase confidence in the veracity of the message, if users already have a formed opinion on the issue. Thus, they can appreciate the complexity and honesty of acknowledging different points of view (Petty and Cacioppo, 1986).

In this regard, the objective of this phase is to understand the effect of environmental priming and the presentation of unilateral or bilateral information on the perception of business center workers regarding the decentralized wastewater treatment system (based on Gómez-Román et al., 2021). The main hypothesis is that environmental priming will positively influence the perception of the building's decentralized plant. Additionally, public perception of decentralized plants is expected to be more favorable when only the advantages of these installations are presented. However, we anticipate a significant interaction between environmental priming and the type of information presented about the plants. Specifically, in the absence of environmental priming, public perception will be more negative when discussing disadvantages than when only advantages are presented. Conversely, in the condition with environmental priming, we expect the perception of decentralized plants to be similar regardless of whether advantages alone or both advantages and disadvantages are presented.

3.1 Materials and methods

3.1.1 Participants and design

A total of 46 workers from the Porto de Molle building participated in this second phase (70.6% men, $M_{age} = 41.06$, $SD = 10.24$). The experimental design was a 2 (priming: environmental

priming vs. company piracy) $\times$ 2 (information: advantages vs. advantages and disadvantages).

3.1.2 Procedure

Recruitment was conducted by two researchers who approached workers in person, going door-to-door throughout the building to ask for their collaboration in a university-led research study. Participants were provided with a link to an online questionnaire on Qualtrics, which they could complete at their convenience on their own devices. The researchers were not present while the participants filled out the survey, ensuring privacy during the process. In the introductory section of the questionnaire, participants were informed about the confidentiality and anonymity of their responses, and the data protection policy was clearly outlined.

Participants were required to provide informed consent. Subsequently, each participant was randomly assigned to one of the experimental conditions. To prepare them for the procedure, participants were first given an example topic along with three questions to familiarize themselves with the format. This introductory step served as the initial priming manipulation. It was followed by the presentation of the informational text, which constituted the other experimental manipulation. Finally, participants were asked questions related to the installation of the decentralized plant.

3.1.2.1 Environmental priming vs. company piracy

The environmental priming consisted of two phases to make the environmental problem accessible. First, the experimental group read a text about the consequences of climate change (see Supplementary material). Second, participants had to respond to the following statements: (a) "I consider these environmental problems to be..." (from 1 = *not serious at all* to 9 = *very serious*), (b) "Addressing these environmental problems is" (from 1 = *not urgent at all* to 9 = *very urgent*) and (c) "As a citizen, I should be more involved in solving these environmental problems" (from 1 = *totally disagree* to 9 = *totally agree*).

The control condition consisted of a text about piracy in companies. This topic was selected because it is neutral with respect to environmental issues, yet relevant to the business context and capable of engaging the interest of workers. By choosing a topic that could generate attention without introducing environmental biases, we ensured that any observed effects could be attributed specifically to the environmental priming, rather than general attitudes or engagement elicited by an unrelated, random topic. Similarly to experimental condition participants had to respond to three questions expressing their opinions on the severity, urgency of the problem, and citizen involvement.

3.1.2.2 Advantages vs. advantages and disadvantages

Once the priming was introduced, participants were informed that they would be answering the research questions. A text about the wastewater treatment plant installed in the building's basement was presented. In the "advantages" condition, only the advantages of the decentralized plant were provided, while in the "advantages and disadvantages" condition, both the advantages and disadvantages were presented (see [Supplementary material](#) for complete information).

3.1.2.3 Priming control

At the end of the questionnaire, participants were asked to answer the following open-ended question: "What do you think is the objective of this research?" This statement allowed us to identify whether or not participants were aware of the experimental manipulation, and if they were, their responses were not included in the analysis (Bargh, 2006; Furnham, 1986). The review of the responses to the open-ended question suggests that no participant identified the manipulation or the study's objective. Participants typically mentioned that the study aimed to understand their perceptions and opinions about the decision to install a plant in the building or to provide information about the existing water treatment. They did not explicitly or implicitly refer to the effect that the first task of the questionnaire (priming) might have on the second part of the study (acceptance of the decentralized plant).

3.1.3 Measures

All the measures were adapted from the study of Gómez-Román et al. (2021).

3.1.3.1 Attitudes toward decentralized plants

Attitudes were measured using a 9-point semantic differential scale consisting of eight items. Participants had to rate to what extent the installation of the decentralized plant in the building was: (a) *very bad* – *very good*, (b) *dislike it very much* – *like it very much*, (c) *very negative* – *very positive*, (d) *very unnecessary* – *very necessary*, (e) *very useless* – *very useful*, (f) *very unacceptable* – *very acceptable*, (g) *very inappropriate* – *very appropriate*, (h) *very harmful* – *very beneficial* ($\alpha = 0.97$, $\omega = 0.97$).

3.1.3.2 Strength of attitudes

The measure consisted of three items in which participants were asked to respond about the opinions they had just given regarding the installation of the decentralized plant in the building: (a) "How convinced are you about your opinions on the decentralized plant?" (from 1 = *not at all convinced* to 9 = *very convinced*), (b) "How confident are you in your opinions about the decentralized plant?"

(from 1 = *no confidence* to 9 = *a lot of confidence*), and (c) "If in a conversation someone disagreed with your opinion about the installation of the decentralized plant, do you think you would change your opinion?" (from 1 = *very easily* to 9 = *very difficultly*) ($\alpha = 0.91$, $\omega = 0.91$).

3.1.3.3 Emotions

Participants were asked to indicate to what extent the installation of the plant in the building made them feel (from 1 = *nothing* to 9 = *a lot*): worried, disgusted, angry, fearful, helpless (negative emotions: $\alpha = 0.84$, $\omega = 0.84$); and relieved, proud, optimistic, enthusiastic, comfortable (positive emotions: $\alpha = 0.72$, $\omega = 0.68$).

3.1.3.4 Behavioral intention

The measure consisted of five items in which participants were asked to respond to the following questions: (a) "If you had to choose between this decentralized plant in the building or the traditional centralized system used by the other buildings in Porto de Molle, would you choose the decentralized plant installed in the building?" (from 1 = *strongly disagree* to 9 = *strongly agree*), (b) "If you had been able to vote for the installation of this decentralized plant in the building, how would you have voted?" (from 1 = *totally against* to 9 = *totally in favor*), (c) "Would you have campaigned in favor of the installation of this decentralized plant in the building?" (d) "Would you recommend installing decentralized plants in other buildings similar to the business center?" and (e) "If you had the necessary financial resources, would you install a decentralized plant in the building/house where you live?" Items c, d, and e were answered on a scale from 1 = *definitely not* to 9 = *definitely yes*. The internal consistency indices for the five items were: $\alpha = 0.90$, $\omega = 0.89$.

3.2 Results and discussion of phase 2

To evaluate whether environmental priming and information (unilateral and bilateral) improved workers' perceptions of the building's decentralized plant, we conducted an univariate analysis of variance for each dependent variable (Levene's test for homogeneity was not significant, as detailed in [Supplementary material](#)). Table 1 shows the detailed results of the effects of environmental priming, information, and their interaction. The results show that participants in the environmental priming condition exhibited more positive attitudes, greater strength in their attitudes, more positive emotions, fewer negative emotions, and greater behavioral intention (similar to Gómez-Román et al., 2021). However, in this study with workers, the priming effect was significant only for attitudes ($F = 5.89$, $p = 0.020$, $\eta^2 = 0.123$).

Regarding the information (unilateral vs. bilateral), participants who read both the advantages and disadvantages of the plant showed fewer positive attitudes, less strength in these attitudes, fewer positive emotions, more negative emotions, and less behavioral intention. However, the effect was significant only for the strength of attitudes ($F = 5.73$, $p = 0.021$, $\eta^2 = 0.120$). These findings contrast with the results found in hypothetical contexts, where presenting the disadvantages alongside the advantages results in less acceptance overall (Gómez-Román et al., 2021). No significant interaction between environmental priming and the information provided is found in the case study context either.

TABLE 1 Univariate analysis: simple effects and interaction of priming and information on acceptance.

Variable	Condition	Condition level	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>	η^2
Attitudes	Priming	Control	23	7.42	1.40	5.89	0.020	0.123
		Environmental	23	8.23	0.81			
	Information	Advantages	25	8.03	1.28	1.93	0.172	0.044
		Advantages + disadvantages	21	7.59	1.09			
	Priming X Information	Control	Advantages	13	7.63	0.001	0.978	0.001
			Advantages + disadvantages	10	7.16			
		Environmental	Advantages	12	8.46			
			Advantages + disadvantages	11	7.98			
Attitudes strength	Priming	Control	23	6.97	1.21	1.38	0.246	0.032
		Environmental	23	7.35	1.43			
	Information	Advantages	25	7.56	1.22	5.73	0.021	0.120
		Advantages + disadvantages	21	6.68	1.32			
	Priming × information	Control	Advantages	13	7.49	0.595	0.445	0.014
			Advantages + disadvantages	10	6.30			
		Environmental	Advantages	12	7.64			
			Advantages + disadvantages	11	7.03			
Negative emotions	Priming	Control	23	3.14	1.50	1.88	0.178	0.043
		Environmental	23	2.49	1.62			
	Information	Advantages	25	2.78	1.78	0.038	0.847	0.001
		Advantages + disadvantages	21	2.85	1.34			
	Priming × information	Control	Advantages	13	3.14	0.036	0.850	0.001
			Advantages + disadvantages	10	3.14			
		Environmental	Advantages	12	2.40			
			Advantages + disadvantages	11	2.58			
Positive emotions	Priming	Control	23	5.71	1.30	3.50	0.068	0.077
		Environmental	23	6.35	0.93			
	Information	Advantages	25	6.08	1.27	0.121	0.730	0.003
		Advantages + disadvantages	21	5.98	1.05			
	Priming × information	Control	Advantages	13	5.77	0.001	0.977	0.001
			Advantages + disadvantages	10	5.64			
		Environmental	Advantages	12	6.40			
			Advantages + disadvantages	11	6.29			
Behavioural intention	Priming	Control	23	7.04	1.75	0.577	0.452	0.014
		Environmental	23	7.41	1.35			
	Information	Advantages	25	7.33	1.74	0.278	0.601	0.007
		Advantages + disadvantages	21	7.10	1.33			
	Priming × information	Control	Advantages	13	7.00	0.486	0.489	0.011
			Advantages + disadvantages	10	7.08			
		Environmental	Advantages	12	7.68			
			Advantages + disadvantages	11	7.11			

In summary, although the observed trends among workers point to their greater disposition toward the plant when only advantages are provided in the environmental priming condition, most of the effects are not significant. There are three reasons that may explain these findings. First, although the number of participants is considerable

given the total number of workers in the building, it is still a small sample size. Second, the life stage and characteristics of workers in a business center are different from those samples commonly used in experimental studies, such as students, that do find significant effects (Gómez-Román et al., 2021). In this sense, and at least in the specific

case of decentralized plants, we believe it is necessary to be cautious about generalizing the results of student samples to the general population (Hanel and Vione, 2016). Third, in contrast to hypothetical situations, in the business center where the plant was already installed, users had experienced certain associated problems. In each context, the personal relevance of the plant to the participants is different; therefore, the degree of information permeability in users' attitudes is also expected to vary.

Exploring these trends in a real context contributes to the knowledge base on the social acceptance of decentralized wastewater treatment plants. It highlights the importance of considering the applicability of results according to the context. Overall, the results emphasize the importance of considering how content is presented. The first contact with information about a new technology establishes an interpretative framework that guides the formation of perceptions and decision-making (Rogers, 2003), and the results suggest that environmental priming remains an element that promotes favorable attitudes toward decentralized treatment plants, even among workers who initially expressed reservations about the installed plant.

4 Phase 3. A bidirectional information session with experts to improve acceptance

The results of the previous phase indicate that making environmental issues accessible through priming improves workers' attitudes toward decentralized treatment plants. However, it's important to note that priming capacity is limited in fostering positive emotions, reducing negative emotions, and increasing behavioral intention. In contexts with high uncertainty, lack of knowledge, and novelty, such as the case study (due to problems arising from technical failure), protection mechanisms against potential threats are activated (Albers, 2012; Slovic et al., 2004). In this sense, the mere association of the plant as a solution to an environmental problem may not be sufficient to modify emotional variables, such as fear, and behavioral variables, such as verbalizing discomfort, associated with decentralized plants. Therefore, adequately communicating the procedures, benefits, and risks of the decentralized plant can help improve understanding (Fischhoff et al., 1993). In this way, the information could facilitate a change in risk perceptions and associated negative emotional reactions (Vila-Tojo et al., 2024). However, while the content of the information is relevant, its interpretation by the public relies more on who and how the information is presented (Entman, 1993).

Trust in the source is key in forming positive or negative perceptions (Ryu et al., 2018). The observable and inferred characteristics of the source, such as competence and intentionality, are crucial for the message's effectiveness (Milburn, 1991; Perloff, 1993; Twyman et al., 2008). In this context, experts, especially scientists, are perceived as credible and trustworthy sources (Cologna and Siegrist, 2020), making them particularly persuasive (Meyer, 1988). While competence-based trust is relevant, intentionality-based trust, linked to the source's honesty and integrity, has a greater influence on the acceptance of new technologies (Liu et al., 2020). This underscores the importance of selecting communicators who possess the necessary technical knowledge and are seen as authoritative and trustworthy sources.

In addition to the characteristics of the source, interactive communication and the opportunity for dialogue are important for building trust and credibility. Allowing questions and encouraging discussions creates a more engaging and trustworthy environment (Brashers, 2001). Research shows that interactive participation significantly improves acceptance of new technologies by addressing concerns and providing real-time clarification (Van den Hooff and De Ridder, 2004; Venkatesh et al., 2003).

Consequently, the third phase of the intervention seeks to establish a bidirectional communicative environment aimed at improving users' perceptions of the decentralized plant. On the one hand, the high reliable source emphasizes environmental issues and presents information about the plant. On the other hand, users can address their doubts and discuss on topics related to the decentralized plant. With these premises, an informative session (workshop) was designed for all Porto de Molle workers who wished to attend.

4.1 Materials and methods

4.1.1 Participants

In the workshop, 25 workers from the business center participated. However, not all of them agreed to complete the questionnaire. Consequently, the final sample consisted of 20 participants (65% men, $M_{age} = 40.56$, $SD = 9.11$). Most of the participants had been working in the building for less than 1 year (*less than 6 months* = 20%, *between 6 months and 1 year* = 40%, *between 1 and 2 years* = 10%, *more than 2 years* = 30%).

4.1.2 Procedure

The workshop took place in the business center building. The building's management sent an email invitation to participate in the session, indicating that the workshop would provide information about the new decentralized plant in the building. A pre-post test intervention was conducted. First, the baseline perception of the decentralized plant installed in the building was measured. Data was collected via a questionnaire before the workshop began. These questions were also asked at the end of the session to find out if there had been a change in attitudes.

The data collection process was structured, with the pre-test questionnaire divided into three parts: an introduction, information about the plant, and questions about its acceptance. The post-test questionnaire, administered after the workshop, was similar to the pre-test, allowing participants to reevaluate their responses and provide additional sociodemographic data.

A technical professional attended the session, providing information on the technology and operation of the decentralized plant. A social psychologist also took part in the session, going in-depth on the aspects of sustainability linked to the implementation of this new technology. At the end of the presentations, participants ask questions and discuss with the experts about the information received.

4.1.3 Measures

4.1.3.1 Attitudes toward decentralized plants

Attitudes were measured using a 9-point semantic differential scale consisting of three items. Participants had to rate to what extent

the installation of the decentralized plant in the building was: (a) *very bad* – *very good*, (b) *very unnecessary* – *very necessary*, (c) *very unacceptable* – *very acceptable* ($\alpha=0.92$, $\omega=0.92$).

4.1.3.2 Emotions

Participants were asked to indicate to what extent the installation of the plant in the building made them feel (from 1 = *nothing* to 9 = *a lot*): worried, disgusted, (negative emotions: $r=0.764$, $p<0.001$); and relieved, proud (positive emotions: $r=0.824$, $p<0.001$).

4.1.3.3 Behavioral intention

Participants were required to respond to items *a* and *d* from phase 2. That is, whether they would choose the decentralized plant installed in the building (from 1 = *strongly disagree* to 9 = *strongly agree*) and if they would recommend installing the decentralized plant in other buildings with similar characteristics to the business center (from 1 = *definitely not* to 9 = *definitely yes*) ($r=0.849$, $p<0.001$).

4.1.3.4 Change of opinion

In order to find out whether the participants recognized a change of opinion in their attitudes after receiving the information, we asked them whether they considered that their opinion of the decentralized plant had changed after the information session (dichotomous: *no* or *yes*). If so, they were asked to indicate whether their opinion had improved or worsened (from 1 = *much worse* to 9 = *much better*). Finally, they were asked to answer the following open-ended question: “If you have changed your opinion, what arguments/information have caused this change?”

4.2 Results and discussion of phase 3

The study’s objective was to examine whether a bidirectional informative session about the operation of the decentralized plant and its added value as a solution to an environmental problem could improve users’ perception of the decentralized plant installed in their building.

The results indicate that the workshop significantly affected the perception of the plant (see Table 2). Specifically, the participants showed a more favorable attitude toward the plant, a reduction in negative emotions, and an increase in both positive emotions and behavioral intention. In this sense, the findings indicate that providing detailed and contextualized information, along with opportunities for

interactive participation, significantly improves technology acceptance (Brashers, 2001; Hou et al., 2021; Ranney and Clark, 2016; Taube et al., 2021).

Overall, the participants stated that their opinion of the decentralized wastewater treatment plant had improved ($M=7.40$, $DT=1.18$). Among the reasons participants cited for their change in opinion, they highlighted the positive environmental impact of the technology, including water savings, nutrient recovery, and environmental value. Additionally, they emphasized the positive impression generated by the technical information, practical examples, and the novelty of the technology. Specifically, the reasons provided by participants suggest that not all types of information are effective. In particular, scientific-technical information communicated by reliable experts allows users to understand the benefits and operation of the plant and to resolve the discomfort and uncertainty associated with it (Liu et al., 2020).

However, a limitation of this study is the low participation in the workshop, with only 10% of the building’s workers attending. Additionally, we do not control for possible overlap between participants across phases. This means that some individuals may have been exposed to the different phases, potentially influencing their responses. Despite this, the consistent positive effects observed in Phase 3 suggest that the workshop was effective, either on its own or through an accumulated effect from exposure across multiple phases. Moreover, since the evaluation of attitudes in Phase 3 was conducted immediately after the intervention, we do not know the stability of this change in perception in the long term. As a consideration for future studies, conducting follow-ups at different times after the intervention would be interesting to verify whether the positive attitude toward the technology is maintained over time and explore strategies to increase participation in these informational events.

5 General discussion and conclusion

Society faces an urgent climate challenge to which we must respond (Wyss et al., 2021). Although technological solutions have already tried to address environmental problems, we should remember that their implementation is conditional on the support received at the political and social level (Dimitrov, 2020; Lahsen and Turnhout, 2021). Decentralized wastewater treatment plants do not always have such citizen support. Overcoming the citizen reluctance requires the design of intervention strategies that consider the barriers detected in each specific context. In this study, we present an intervention carried out in a business center, which is of particular interest due to the discomfort generated by a technical failure in installing the decentralized wastewater treatment plant (of whose existence users were unaware). In this intervention, uncertainty was addressed through the mitigation of the associated epistemic demand (Sabucedo et al., 2020). In new and unknown situations, people need information that allows them to position themselves and make decisions.

This scenario led us to propose a first phase that consists of a focus group that would allow us to identify the main barriers associated with the plant and initiate a communication channel with users. The results showed a negative perception of the plant similar to works in other contexts (Koetse, 2005; Mankad and Tapsuwan, 2011; Rygaard et al., 2014). The participants’ verbalization of more disadvantages than advantages allow for three observations. First, there is a strong

TABLE 2 Mean differences between pre-test and post-test on the acceptance variables.

Variable	Pre-test		Post-test		<i>t</i>	<i>p</i>	Cohen’s <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Attitudes	6.28	0.89	7.90	0.71	−6.34	<0.001	0.81
Negative emotions	5.45	1.28	2.42	1.37	7.23	<0.001	1.32
Positive emotions	5.05	1.41	7.25	1.25	−5.21	<0.001	1.34
Behavioural intention	6.00	1.27	7.83	0.89	−5.27	<0.001	1.10

psychological distance (Keller et al., 2022). Users recognize the value of the decentralized plant in solving environmental problems. However, at the same time, they do not perceive a problem in the area, making the plant seem unnecessary to them. Second, the opinion about the cost–benefit of the plant is not uniform; users verbalize concern about the cost of maintaining the plant while recognizing its low operating cost and ease of installation (Ho and Anda, 2006). Third, the “yuck factor” is one of the main variables associated with users’ discomfort, related to concerns about the smell and color of the water (Rozin et al., 2015; Wester et al., 2016).

With these observations, we proposed a second phase to activate environmental concerns and provide information about the plant’s advantages and disadvantages that would alleviate discomfort and uncertainty. The findings showed that activating environmental concern (through priming) is related with higher attitudes toward the technology. However, priming effect on negative emotions, positive emotions and behavioral intention was not significant. In this regard, it is important to consider the ongoing debate about the replicability of priming experiments (Chivers, 2019; Rohrer et al., 2019).

Therefore, in the third phase, we opted to design a workshop based on trust in the source and focused on informing about the plant’s properties and its capacity to solve a concerning environmental problem. The perception and emotions associated with the plant improved significantly after the informational session. This change underscores how framing is an important element for persuasion (Benford and Snow, 2000), especially in contexts of uncertainty, such as the case at hand. In such situations, people are more receptive to messages that alleviate their uncertainty, especially if they come from reference groups (Schultz and Fielding, 2014). In this sense, the workshop results showed, as has been pointed out many times in the literature, the significant role of scientists as a source of trust for environmental issues (Cologna and Siegrist, 2020). Due to their training and experience, they are seen as reliable and objective experts, increasing public receptivity to the information presented (Meyer, 1988). However, we must remember that they also need to align the presented information with the real expectations and concerns of the public (Sawyer and Ball, 1981). This matter is particularly relevant because scientists are not the only reference group for users. Other trusted agents could capitalize on discontent and channel uncertainty toward positions and actions contrary to the decentralized system. In future studies, it would be advisable to explore the effect of the interaction of different sources of influence on the acceptance of plants. For example, the intervention was coordinated by university profiles that generally receive positive public evaluations. Such an academic context could have influenced the favorable response of the building users (Sanz-Menéndez and Cruz-Castro, 2017).

Alongside the contributions of the use of reliable sources to transmit technical and environmental information, this third phase also emphasizes the relevance of active user participation to alleviate uncertainty. Receiving information passively can have a reduced effect if it is not accompanied by other techniques (Schultz, 1998). In contrast, interactive interventions allow for the expression of opinions and provide spaces for discussion to foster acceptance. On the one hand, they contribute to the decision not being perceived as externally imposed. On the other hand, they increase commitment to the decisions made (Lewin, 1943; Jans, 2021).

The intervention presented in this work indicates that the acceptance of decentralized plants, as with other behaviors,

depends on the beliefs developed during social interaction (Jaspal and Breakwell, 2014). Therefore, it is important to incorporate (potential) users throughout the entire process, from beginning to end, with the aim of weaving complicity between promoters and users and generating a climate of co-responsibility regarding the plant. This participatory approach helps to prevent the emergence of psychosocial resistance and can also alleviate existing doubts and misgivings about the operation of decentralized plants. Engaging community members from the outset fosters ownership, making them more likely to support the adoption of such technologies, as they feel heard and actively involved in the decision-making process.

While this study focused on a business center, the intervention protocol can be adapted to other settings, such as residential areas or different cultural contexts. For example, in residential communities, the focus group phase could be adapted into neighborhood meetings to address local concerns, and the workshop could include more context-specific examples that make the benefits of decentralized systems relatable. Implementing this protocol in diverse cultural settings would also require careful attention to local norms, trust in authorities, and perceptions of water reuse (Vila-Tojo et al., 2022). Tailoring the intervention to address these factors would enhance acceptance, making the findings more generalizable across different contexts.

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 humans were approved by Santiago de Compostela bioethics committee (PSY-1819-S-0218). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SV-T: Formal analysis, Investigation, Writing – original draft, Writing – review & editing. CG-R: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. J-MS: Conceptualization, Funding acquisition, Methodology, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research has received funding from the European Union’s Horizon 2020 research and innovation program (No. 730285) and from the Galician Department of Education, University, and Professional Training (grant number ED431B 2019/07), and from the Spanish Ministry of

Science, Innovation, and Universities through the D-PATTERN project (PID2023-150071OB-I00). The authors belong to the Galician Competitive Research Group COSOYA (GPC2022 GI-1456), and to the Cross-Disciplinary Research Center in Environmental Technologies (CRETUS) (AGRUP2015/02). These programs are supported by the European Regional Development Fund of the European Union (ERDF).

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.

References

- Albers, M. J. (2012). Human-information interaction and technical communication: concepts and frameworks. Hershey, PA: IGI Global.
- Allen, M. (1991). Meta-analysis comparing the persuasiveness of one-sided and two-sided messages. *West. J. Speech Commun.* 55, 390–404. doi: 10.1080/10570319109374395
- Bargh, J. A. (2006). What have we been priming all these years? On the development, mechanisms, and ecology of nonconscious social behavior. *Eur. J. Soc. Psychol.* 36, 147–168. doi: 10.1002/ejsp.336
- Bauer, M. W., Allum, N., and Miller, S. (2007). What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. *Public Underst. Sci.* 16, 79–95. doi: 10.1177/0963662506071287
- Benford, R. D., and Snow, D. A. (2000). Framing processes and social movements: an overview and assessment. *Annu. Rev. Sociol.* 26, 611–639. doi: 10.1146/annurev.soc.26.1.611
- Bisschops, I., Kjerstad, H., Meulman, B., and van Eekert, M. (2019). Integrated nutrient recovery from source-separated domestic wastewaters for application as fertilisers. *Curr. Opin. Environ. Sustain.* 40, 7–13. doi: 10.1016/j.cosust.2019.06.010
- Bowen, G. A. (2008). Naturalistic inquiry and the saturation concept: a research note. *Qual. Res.* 8, 137–152. doi: 10.1177/1468794107085301
- Brashers, D. E. (2001). Communication and uncertainty management. *J. Commun.* 51, 477–497. doi: 10.1111/j.1460-2466.2001.tb02892.x
- Brouwer, S., Maas, T., Smith, H., and Frijs, J. (2015). Trust in water reuse: review report on international experiences in public involvement and stakeholder collaboration. *DEMOWARE*, 1–47.
- Chivers, T. (2019). What's next for psychology's embattled field of social priming. *Nature* 576, 200–202. doi: 10.1038/d41586-019-03755-2
- Cologna, V., and Siegrist, M. (2020). The role of trust for climate change mitigation and adaptation behaviour: a meta-analysis. *J. Environ. Psychol.* 69:101428. doi: 10.1016/j.jenvp.2020.101428
- Cruzes, D. S., and Dyba, T. (2011). Recommended steps for thematic synthesis in software engineering. In 2011 International symposium on empirical software engineering and measurement (pp. 275–284).
- Custers, R., and Aarts, H. (2010). The unconscious will: how the pursuit of goals operates outside of conscious awareness. *Science* 329, 47–50. doi: 10.1126/science.1188595
- Dimitrov, R. S. (2020). Empty institutions in global environmental politics. *Int. Stud. Rev.* 22, 626–650. doi: 10.1093/isr/viz029
- Domènech, L., and Saurí, D. (2010). Socio-technical transitions in water scarcity contexts: public acceptance of greywater reuse technologies in the metropolitan area of Barcelona. *Resour. Conserv. Recycl.* 55, 53–62. doi: 10.1016/j.resconrec.2010.07.001
- Ellis, S. F., Savchenko, O. M., and Messer, K. D. (2021). Mitigating stigma associated with recycled water. *Am. J. Agric. Econ.* 104, 1077–1099. doi: 10.1111/ajae.12256
- Entman, R. M. (1993). Framing: toward clarification of a fractured paradigm. *J. Commun.* 43, 51–58. doi: 10.1111/j.1460-2466.1993.tb01304.x
- Etale, A., Fielding, K., Schäfer, A. I., and Siegrist, M. (2020). Recycled and desalinated water: Consumers' associations, and the influence of affect and disgust on willingness to use. *J. Environ. Manag.* 261:110217. doi: 10.1016/j.jenvman.2020.110217
- Fielding, K. S., Dolnicar, S., and Schultz, T. (2018). Public acceptance of recycled water. *Int. J. Water Resour. Dev.* 35, 551–586. doi: 10.1080/07900627.2017.1419125
- Fischhoff, B., Bostrom, A., and Quadrel, M. J. (1993). Risk perception and communication. *Annu. Rev. Public Health* 14, 183–203. doi: 10.1146/annurev.pu.14.050193.001151
- Furnham, A. (1986). Response bias, social desirability and dissimulation. *Personal. Individ. Differ.* 7, 385–400. doi: 10.1016/0191-8869(86)90014-0
- Gómez-Román, C., Lima, L., Vila-Tojo, S., Correa-Chica, A., Lema, J., and Sabucedo, J. M. (2020). "Who cares?" The acceptance of decentralized wastewater systems in regions without water problems. *Int. J. Environ. Res. Public Health* 17:9060. doi: 10.3390/ijerph17239060
- Gómez-Román, C., Sabucedo, J.-M., Alzate, M., and Medina, B. (2021). Environmental concern priming and social acceptance of sustainable technologies: the case of decentralized wastewater treatment systems. *Front. Psychol.* 12:12. doi: 10.3389/fpsyg.2021.647406
- Gramsci, A. (1971). Selections from the prison notebooks. London: Lawrence and Wishart.
- Gustafson, A., and Rice, R. E. (2016). Cumulative advantage in sustainability communication: unintended implications of the knowledge deficit model. *Sci. Commun.* 38, 800–811. doi: 10.1177/1075547016674320
- Haddad, B., Heck, N., Paytan, A., and Potts, D. (2018). "Social issues and public acceptance of seawater desalination plants" in Sustainable desalination handbook: plant selection, design and implementation. ed. V. Gnanaswar-Gude (Oxford, United Kingdom: Butterworth-Heinemann), 505–525.
- Hanel, P. H. P., and Vione, K. C. (2016). Do student samples provide an accurate estimate of the general public? *PLoS One* 11:e0168354. doi: 10.1371/journal.pone.0168354
- Hao, X., Wang, X., Liu, R., Li, S., van Loosdrecht, M. C. M., and Jiang, H. (2019). Environmental impacts of resource recovery from wastewater treatment plants. *Water Res.* 160, 268–277. doi: 10.1016/j.watres.2019.05.068
- Ho, G., and Anda, M. (2006). Centralised versus decentralised wastewater systems in an urban context: the sustainability dimension. In M. Beck and A. Speers (Eds.), Proceedings of the 2nd IWA leading-edge conference on sustainability (pp. 80–89). Sydney: IWA Publishing.
- Hou, C., Wen, Y., Liu, X., and Dong, M. (2021). Impacts of regional water shortage information disclosure on public acceptance of recycled water — evidence from China's urban residents. *J. Clean. Prod.* 278:123965. doi: 10.1016/j.jclepro.2020.123965
- Hurlimann, A., and Dolnicar, S. (2010). When public opposition defeats alternative water projects — the case of Toowoomba Australia. *Water Res.* 44, 287–297. doi: 10.1016/j.watres.2009.09.020
- Jans, L. (2021). Changing environmental behavior from the bottom up: the formation of pro-environmental social identities. *J. Environ. Psychol.* 73:101531. doi: 10.1016/j.jenvp.2020.101531
- Jaspal, R., and Breakwell, G. M. (Eds.) (2014). Identity process theory: identity, social action and social change. Cambridge, United Kingdom: Cambridge University Press.
- Jonas, K., and Sassenberg, K. (2006). Knowing what to do: response behavior activation from social category primes. *J. Pers. Soc. Psychol.* 90, 709–721. doi: 10.1037/0022-3514.90.5.709
- Keller, E., Marsh, J. E., Richardson, B. H., and Ball, L. J. (2022). A systematic review of the psychological distance of climate change: towards the development of an evidence-based construct. *J. Environ. Psychol.* 81:101822. doi: 10.1016/j.jenvp.2022.101822
- Koetse, E. (2005). The implementation of DESAR concepts in two projects in Germany. Available at: http://www.switchurbanwater.eu/outputs/pdfs/W4-1_GEN_PHD_Implementation_of_DESAR_concepts_in_two_projects_in_Germany_-_Koetse.pdf

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1445320/full#supplementary-material>

- Krueger, R. A., and Casey, M. A. (1994). Focus groups: a practical guide for applied research. 2nd Edn. Thousand Oaks, California, USA: Sage.
- Lahsen, M., and Turnhout, E. (2021). How norms, needs, and power in science obstruct transformations towards sustainability. *Environ. Res. Lett.* 16:025008. doi: 10.1088/1748-9326/abdcf0
- Lamichhane, K. M., and Babcock, R. W. (2013). Survey of attitudes and perceptions of urine-diverting toilets and human waste recycling in Hawaii. *Sci. Total Environ.* 443, 749–756. doi: 10.1016/j.scitotenv.2012.11.039
- Lens, P., Zeeman, G., and Lettinga, G. (Eds.) (2005). Decentralised sanitation and reuse: concepts, systems and implementation. London, UK: IWA Publishing.
- Lewin, K. (1943). The problem of changing food habits: report of the committee on food habits 1941–1943. Washington, DC: National Academies Press (US).
- Lewis, G. B., Palm, R., and Feng, B. (2019). Cross-national variation in determinants of climate change concern. *Environ. Polit.* 28, 793–821. doi: 10.1080/09644016.2018.1512261
- Liu, L., Bouman, T., Perlaviciute, G., and Steg, L. (2020). Effects of competence- and integrity-based trust on public acceptability of renewable energy projects in China and the Netherlands. *J. Environ. Psychol.* 67:101390. doi: 10.1016/j.jenvp.2020.101390
- Liu, X., Chen, S., Guo, X., and Fu, H. (2022). Can social norms promote recycled water use on campus? The evidence from event-related potentials. *Front. Psychol.* 13:818292. doi: 10.3389/fpsyg.2022.818292
- Mankad, A. (2012). Decentralised water systems: emotional influences on resource decision making. *Environ. Int.* 44, 128–140. doi: 10.1016/j.envint.2012.01.002
- Mankad, A., and Tapsuwan, S. (2011). Review of socio-economic drivers of community acceptance and adoption of decentralised water systems. *J. Environ. Manag.* 92, 380–391. doi: 10.1016/j.jenvman.2010.10.037
- Mankad, A., Tucker, D., Tapsuwan, S., and Greenhill, M. P. (2010). Qualitative exploration of beliefs, values, and knowledge associated with decentralised water supplies in South East Queensland communities. Urban Water Security Research Alliance Technical Report No. 25. City East, Queensland, Australia: Urban Water Security Research Alliance.
- Meyer, P. (1988). Defining and measuring credibility of newspapers: developing an index. *Journal. Q.* 65, 567–574. doi: 10.1177/107769908806500301
- Milburn, M. A. (1991). Persuasion and politics: the social psychology of public opinion. Pacific Grove, CA: Brooks/Cole Publishing.
- Moglia, M., Sharma, A., Alexander, K., and Mankad, A. (2011). Perceived performance of decentralised water systems: a survey approach. *Water Sci. Technol. Water Supply.* 11, 516–526. doi: 10.2166/ws.2011.081
- Morgan, D. L. (1997). Focus groups as qualitative research. 2nd Edn. Thousand Oaks, California, USA: Sage.
- Nancarrow, B. E., Porter, N. B., and Leviston, Z. (2010). Predicting community acceptability of alternative urban water supply systems: a decision making model. *Urban Water J.* 7, 197–210. doi: 10.1080/1573062X.2010.484500
- Perloff, R. M. (1993). The dynamics of persuasion. Hillsdale, NJ: Lawrence Erlbaum.
- Petty, R. E., and Cacioppo, J. T. (1986). “The elaboration likelihood model of persuasion,” in *Advances in Experimental Social Psychology*. ed. E. L. Berkowitz (New York: Academic Press), 19, 123–205.
- Po, M., Kaercher, J. D., and Nancarrow, B. E. (2003). Literature review of factors influencing public perceptions of water reuse. Adelaide, SA, Australia: CSIRO Land and Water, Technical Report 54/03. Available at: <https://www.clearwatervic.com.au/user-data/research-projects/swf-files/16-laying-the-foundation-for-confident-barrier-free-water-conservation-and-reuse-literature-review.pdf>
- Poortinga, W., Whitmarsh, L., Steg, L., Böhm, G., and Fisher, S. (2019). Climate change perceptions and their individual-level determinants: a cross-European analysis. *Glob. Environ. Chang.* 55, 25–35. doi: 10.1016/j.gloenvcha.2019.01.007
- Ranney, M. A., and Clark, D. (2016). Climate change conceptual change: scientific information can transform attitudes. *Top. Cogn. Sci.* 8, 49–75. doi: 10.1111/tops.12187
- Roefs, I., Meulman, B., Vreeburg, J., and Spiller, M. (2017). Centralised, decentralised or hybrid sanitation systems? Economic evaluation under urban development uncertainty and phased expansion. *Water Res.* 109, 274–286. doi: 10.1016/j.watres.2016.11.051
- Rogers, E. M. (2003). Diffusion of innovations. 5th Edn. New York: Free Press.
- Rohrer, D., Pashler, H., and Harris, C. R. (2019). Discrepant data and improbable results: an examination of Vohs, Mead, and Goode (2006). *Basic Appl. Soc. Psychol.* 41, 263–271. doi: 10.1080/01973533.2019.1624965
- Ross, V. L., Fielding, K. S., and Louis, W. R. (2014). Social trust, risk perceptions and public acceptance of recycled water: testing a social-psychological model. *J. Environ. Manag.* 137, 61–68. doi: 10.1016/j.jenvman.2014.01.039
- Rozin, P., Haddad, B., Nemeroff, C., and Slovic, P. (2015). Psychological aspects of the rejection of recycled water: contamination, purification and disgust. *Judgm. Decis. Mak.* 10, 50–63. doi: 10.1017/S193029750000317X
- Rygaard, M., Godsken, B., Jørgensen, C., and Hoffmann, B. (2014). Holistic assessment of a secondary water supply for a new development in Copenhagen, Denmark. *Sci. Total Environ.* 497–498, 430–439. doi: 10.1016/j.scitotenv.2014.07.078
- Ryu, Y., Kim, S., and Kim, S. (2018). Does trust matter? Analyzing the impact of trust on the perceived risk and acceptance of nuclear power energy. *Sustain. For.* 10:758. doi: 10.3390/su10030758
- Sabucedo, J. M., Alzate, M., and Gómez-Román, C. (2020). “Extremismos e secesionismo em contextos de crise. O movimento indoeuropeista na Catalunha/Espanha” in *Psicologia Dos Extremismos Políticos*. eds. D. U. Hur and J. M. Sabucedo (Petrópolis, Brazil: Editora Vozes), 16–41.
- Sanz-Menéndez, L., and Cruz-Castro, L. (2017). La investigación en España: Las actitudes de empresas, gobiernos y ciudadanos. El Observatorio Social de la Fundación “la Caixa”. Available at: <https://elobservatoriosocial.fundacionlacaixa.org/es/-/la-investigacion-en-espana-las-actitudes-de-empresas-gobiernos-y-ciudadan-1>
- Sawyer, A. G., and Ball, D. (1981). Statistical power and effect size in marketing research. *J. Mark. Res.* 18, 275–290. doi: 10.1177/002224378101800302
- Scheufele, D. A., and Tewksbury, D. (2007). Framing, agenda-setting, and priming: the evolution of three media effects models. *J. Commun.* 57, 9–20. doi: 10.1111/j.0021-9916.2007.00326.x
- Schultz, P. W. (1998). Changing behavior with normative feedback interventions: a field experiment on curbside recycling. *Basic Appl. Soc. Psychol.* 21, 25–36. doi: 10.1207/s15324834bas2101_3
- Schultz, P. W. (2002). “Knowledge, information, and household recycling: examining the knowledge-deficit model of behavior change” in New tools for environmental protection: education, information, and voluntary measures. eds. T. Dietz and P. C. Stern (Washington, DC: National Academies Press), 67–82.
- Schultz, T., and Fielding, K. (2014). The common in-group identity model enhances communication about recycled water. *J. Environ. Psychol.* 40, 296–305. doi: 10.1016/j.jenvp.2014.07.006
- Simha, P., and Ganesapillai, M. (2017). Ecological sanitation and nutrient recovery from human urine: how far have we come? A review. *Sustain. Environ. Res.* 27, 107–116. doi: 10.1016/j.serj.2016.12.001
- Singh, N. K., Kazmi, A. A., and Starkl, M. (2014). A review on full-scale decentralized wastewater treatment systems: techno-economical approach. *Water Sci. Technol.* 71, 468–478. doi: 10.2166/wst.2014.413
- Slovic, P., Finucane, M. L., Peters, E., and MacGregor, D. G. (2004). Risk as analysis and risk as feelings: some thoughts about affect, reason, risk, and rationality. *Risk Anal.* 24, 311–322. doi: 10.1111/j.0272-4332.2004.00433.x
- Taube, O., Ranney, M. A., Henn, L., and Kaiser, F. G. (2021). Increasing people's acceptance of anthropogenic climate change with scientific facts: is mechanistic information more effective for environmentalists? *J. Environ. Psychol.* 73:101549. doi: 10.1016/j.jenvp.2021.101549
- Thomas, J., and Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Med. Res. Methodol.* 8:45. doi: 10.1186/1471-2288-8-45
- Twyman, M., Harvey, N., and Harries, C. (2008). Trust in motives, trust in competence: separate factors determining the effectiveness of risk communication. *Judgm. Decis. Mak.* 3, 111–120. doi: 10.1017/S1930297500000218
- Van den Hooff, B., and De Ridder, J. A. (2004). Knowledge sharing in context: the influence of organizational commitment, communication climate, and CMC use on knowledge sharing. *J. Knowl. Manag.* 8, 117–130. doi: 10.1108/13673270410567675
- Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Q.* 27, 425–478. doi: 10.2307/30036540
- Vila-Tojo, S., Sabucedo, J. M., Andrade, E., and Gómez-Román, C. (2024). A perceptual-emotional model of behavioural intention to consume food grown with nutrients recovered from wastewater. *Resour. Conserv. Recycl.* 202:107386. doi: 10.1016/j.resconrec.2023.107386
- Vila-Tojo, S., Sabucedo, J.-M., Andrade, E., Gómez-Román, C., Alzate, M., and Seoane, G. (2022). From scarcity problem diagnosis to recycled water acceptance: a perceptual-axiological model (PAM) of low and high contact uses. *Water Res.* 217:118380. doi: 10.1016/j.watres.2022.118380
- Watts, L. L., Todd, E. M., Mulhearn, T. J., Medeiros, K. E., Mumford, M. D., and Connolly, S. (2017). Qualitative evaluation methods in ethics education: a systematic review and analysis of best practices. *Account. Res.* 24, 225–242. doi: 10.1080/08989621.2016.1274975
- Wester, J., Timpano, K. R., Çek, D., and Broad, K. (2016). The psychology of recycled water: factors predicting disgust and willingness to use. *Water Resour. Res.* 52, 3212–3226. doi: 10.1002/2015WR018340
- Wibeck, V. (2014). Enhancing learning, communication and public engagement about climate change: some lessons from recent literature. *Environ. Educ. Res.* 20, 387–411. doi: 10.1080/13504622.2013.812720
- Wyss, A. M., Berger, S., Baumgartner, T., and Knoch, D. (2021). Reactions to warnings in the climate commons. *J. Environ. Psychol.* 78:101689. doi: 10.1016/j.jenvp.2021.101689
- Yates, J. F., and Stone, E. R. (1992). “The risk construct” in Risk-taking behavior. ed. J. F. Yates (Chichester, England: John Wiley & Sons), 1–25.



OPEN ACCESS

EDITED BY
Christian Andreas Klöckner,
NTNU, Norway

REVIEWED BY
Oriana Mosca,
University of Cagliari, Italy
Carly Maynard,
Scotland's Rural College, United Kingdom

*CORRESPONDENCE
Paul Haggar
✉ ph640@bath.ac.uk

RECEIVED 16 July 2024
ACCEPTED 24 October 2024
PUBLISHED 13 November 2024

CITATION
Mitev K, Rennison F, Haggar P, Hafner R,
Lowe A and Whitmarsh L (2024) Encouraging
water-saving behavior during a "Moment of
Change": the efficacy of implementation
intentions on water conservation during the
transition to university.
Front. Psychol. 15:1465696.
doi: 10.3389/fpsyg.2024.1465696

COPYRIGHT
© 2024 Mitev, Rennison, Haggar, Hafner,
Lowe and Whitmarsh. This is an open-access
article distributed under the terms of the
[Creative Commons Attribution License \(CC
BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or reproduction in
other forums is permitted, provided the
original author(s) and the copyright owner(s)
are credited and that the original publication
in this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Encouraging water-saving behavior during a "Moment of Change": the efficacy of implementation intentions on water conservation during the transition to university

Kaloyan Mitev¹, Freya Rennison¹, Paul Haggar^{1*},
Rebecca Hafner², Alice Lowe³ and Lorraine Whitmarsh¹

¹Department of Psychology, University of Bath, Bath, United Kingdom, ²School of Psychology, Swansea University, Swansea, United Kingdom, ³Climate Action Team, University of Bath, Bath, United Kingdom

Water saving behavior is of substantial importance in climate change mitigation and resilience, including reducing time spent in the shower. However, water use is, for many, a strong habit, and, as such, incorporating new water saving behaviors into one's domestic routines may be unsuccessful. In this study, we consider the extent to which a composite behavior change intervention (of water-saving information, implementation intention formation, and monitoring using a shower timer) is effective in reducing the domestic water consumption of new university students who have recently moved into university accommodation. We focus on aspects of the habit discontinuity hypothesis, namely that a natural moment of change facilitates behavior change by weakening existing habits. The intervention was found to be effective, increasing the frequency of self-reported water-saving behavior over behavior measured in a control group. However, shower times, and water usage (measured at the residential level), were not affected by the intervention, and strength of existing habits, readiness to change water behavior, and recency of starting university were each not significantly associated with the effectiveness of the intervention. However, all participants (irrespective of intervention) increased water-saving behavior and reduced shower time during the study, with residential water usage being less for residences with more participating students. Contrary to expectations, the timing of the intervention did not show a clear effect upon the efficacy of the intervention. We discuss these findings with respect to moments of change and habit discontinuity theory as well as implications for practical behavior change interventions.

KEYWORDS

water use, university student, moment of change, habit discontinuity, implementation intention

Introduction

The management and treatment of freshwater accounts for a large proportion of global energy consumption (IEA, 2017) and produces methane and nitrous oxide emissions (Crippa et al., 2020). Demand for freshwater is increasing due to urbanization and development, while water availability is declining due to climate

change (He et al., 2021; Finley and Basu, 2020). For example, in England, the Environment Agency predicts that the country will be short of 3,435 million liters per day by 2050 (Environment Agency, 2020). Therefore, there is an imperative to reduce water consumption, both to mitigate, and to adapt to, climate change. Reducing household demand for water is an essential part of reducing overall water usage (Environment Agency, 2020) and the UK government has identified supporting households to reduce their water use as a key element of managing the UK's water supply (DEFRA, 2023).

Despite this urgency, research focused on changing behavior around water use has found mixed results. For instance, interventions focusing on providing information about water usage are not consistently effective in reducing water consumption (Grilli and Curtis, 2021) and water usage is insensitive to changes in price, particularly when money is not a priority (Garcia-Valiñas et al., 2014; Goette et al., 2019; Tijs et al., 2017). One possible explanation is the role of habits, which are a relatively good predictor of water usage (Garcia-Valiñas et al., 2014; Gregory and Leo, 2003). A habit is an automatic association between a contextual cue and a response (e.g., Rebar et al., 2018; Verplanken and Aarts, 1999), which is formed through repetition and is context dependent (Gardner and Lally, 2018). Usually, habitual behavior is carried out via an unconscious association between cue and action (Verplanken and Aarts, 1999) and this property of automaticity makes many environmental behaviors difficult to change or cultivate. Without conscious deliberation, people's good intentions may not match their automatic, less deliberative habits (Gardner, 2009; Fujii and Garling, 2005).

Consequently, changing the environments which trigger habits might provide a way toward behavior change (Carden and Wood, 2018). When a person's context changes, they are no longer exposed to the contextual cues that automatically trigger their behaviors. This disruption in context might create a window of opportunity, during which a person's behaviors are more conscious, and therefore more susceptible to behavioral interventions (Verplanken et al., 2018). This idea is known as the "Habit Discontinuity Hypothesis" (Verplanken et al., 2018).

In fact, there are certain periods in people's lives which represent natural changes to people's physical and/or social environments which are known as *Moments of Change* (MoCs) and could constitute instances of habit discontinuity (Verplanken et al., 2018). Some examples include residential relocation, becoming a parent for the first time, and work retirement. In addition, research suggests that behavioral interventions might be more effective when applied during MoCs (Verplanken and Whitmarsh, 2021). For example, transport interventions have been found to be more effective when participants have recently moved house and/or job (Thøgersen, 2012; Ralph and Brown, 2019), while Maréchal (2010) found that residents who had recently moved house were more likely to apply for energy subsidies. Considering water consumption and MoCs, one study found the average length of showers decreased after the disruption of the Covid pandemic (Swaffield et al., 2023), while another reported that participants who had moved house more recently were more likely to maintain new water-saving habits—suggesting that contextual change enables

habit change (Dean et al., 2021). Taken together, these findings suggest targeting water consumption during MoCs may be an effective way of influencing behavior change.

An understudied but important MoC is the start of university. In 2023, 35.8% of 18-year-olds in the UK started an undergraduate degree (Bolton, 2024). This makes the start of university one of the most widespread MoCs that young people go through during early adulthood. In addition to starting a course of study, the start of university often also entails changes in both the physical and social environments and students residentially relocate to live on or near the university campus. Furthermore, most incoming students in the UK are between 16 and 18 years of age, starting university after completing their secondary education. For these students, starting university coincides with an important developmental period, i.e., late adolescence, defined by a focus on self-exploration (Arnett, 2016), identity formation (Erikson, 1968), and increasing personal independence (Drake et al., 2016). This period is characterized by resistance to parental persuasion, increased self-determination, nonconformity, an internal locus of control, and instrumentality (Beyers et al., 2003). As such, for many of these students, the start of university may also be an important moment for experimenting with new behaviors and lifestyles that reflect personal identity, some of which will stick with them in the long-term. Finally, interventions involving participants in their late adolescence have demonstrated success in altering behavioral practices over the long term (Borman et al., 2018; Hayes et al., 2019). This suggests that conducting interventions with young people going through a MoC, such as starting university, might provide an important pathway to pro-environmental behavior change including water use. This is the focus of the present paper.

However, there is no consensus on how close in time to a MoC an intervention must be introduced in order for it to be most effective. For example, Verplanken and Roy (2016) tested an intervention to foster a range of pro-environmental behaviors and found that it was more effective for participants who had recently relocated, but only if they had relocated in the last 3 months. This suggests that the first 3 months following a MoC might offer a 'window of opportunity' critical for a successful behavioral intervention (cf. Lally et al., 2010). Similarly, Schäfer et al. (2012) suggest that 6 months after a MoC might be too late for an intervention to capitalize on habit discontinuity. Thomas et al. (2016), by contrast, found residential relocation increased the probability of attitude-led car-use reduction within a few months of the event, but also found evidence for some reduction up to 12 or even 24 months after the event. Therefore, this research also tests the idea of a window of opportunity for applying interventions during MoCs by conducting the intervention twice—first with students who had just started university in the previous 1–2 months, and then with students who had started university 5–6 months prior to taking part.

While implementing behavioral interventions within a MoC might enhance their efficacy, the intervention approach also plays a crucial role in maximizing potential outcomes. One commonly used method to promote pro-environmental behaviors (PEBs) involves providing information regarding the consequences of climate change and the significance of engaging in PEBs. However, solely relying on an informational campaign alone typically yields

less effective results than when information is integrated with other strategies in a composite intervention, particularly for changing habitual behavior (Whitmarsh et al., 2021). Therefore, in the present research, we combined an informational campaign with a habit-breaking intervention (implementation intentions) and performance feedback (providing participants with a shower timer).

Implementation intentions is a method of changing behavior that can be especially effective in breaking habits (Gollwitzer and Oettingen, 2020). This method involves a person creating an “if-then” plan in which they associate a contextual cue (e.g., an event or circumstance) with a new behavior (e.g., if I leave the kitchen, then I will turn the light off). This new contingency is formed to replace the existing, undesired, habit with a deliberate alternative action, the plan likely also increasing one’s awareness of the existing environmental cues (Aarts et al., 1999). Such interventions have been successful in a range of domains, including changing recycling and transport behaviors (Holland et al., 2006; Rise et al., 2003; Bamberg, 2000). Although setting targets for water consumption has had some success in a previous study (Walton and Hume, 2011), to the best of our knowledge, implementation intentions specifically have not been tested on water-saving behaviors.

Providing performance feedback about goal-focused tasks can help people meet these goals because knowing whether their current efforts are successful allows them to alter or maintain their approach accordingly in the pursuit of continuing success (Locke and Latham, 2002). Hence, providing this information regarding task performance has often been used as an aspect of goal-directed interventions (Locke and Latham, 2002; Osbaldiston and Schott, 2012; Haggard et al., 2023). In our research, a shower timer was provided to the experimental group so participants can use shower-time information to improve their performance of this behavior, which has a substantial impact upon domestic water-use (Waterwise, 2024).

In addition to the attributes of the MoC and the intervention strategy, there are likely to be individual factors which enhance or inhibit behavior change. Habit strength, particularly the dimension of automaticity (action without conscious deliberation), is associated with the maintenance of behavior (Verplanken and Orbell, 2003; Gardner et al., 2012). Hence, we would expect the intervention strategy might be more effective for those participants with weaker existing habits and for those participants experiencing a MoC, for whom stronger habits may be temporarily weaker (Verplanken et al., 2018) but less effective for others with strong habits, who may habitually neglect the information (Verplanken and Aarts, 1999) or otherwise follow established routines automatically. Readiness to change may also affect intervention efficacy: while some people may have been considering water-reductions for some time, the idea of reducing personal water-use may be quite novel to others. In the transtheoretical model of behavior change, people who successfully change their behavior are described as moving through five discrete stages of change, from giving the idea little consideration (precontemplation) to thinking about it, planning how to execute a change, putting the change into effect, and then maintaining the change for an extended period (Prochaska and DiClemente, 1983). Research shows that those further along in these five-stages,

and hence more “ready to change”, are also more receptive to implementation intention interventions (Bell et al., 2016; Armitage and Arden, 2008), implying that the success of our composite intervention may depend upon existing readiness to change, with those in the earliest stage potentially entirely unreceptive. More broadly, in predicting or explaining the failure of behavior changes within intervention studies in the field, other inhibiting factors upon change exist, particularly more embedded issues such as the design of the material water system, with its emphasis upon convenience over conservation, and existing social norms and culture expectations around water-use and cleanliness (Hand et al., 2005).

In this article, we report the results of a study of students starting their first year of university to consider how a composite intervention may be enhanced during this MoC, assessing behavior change across a three-week period. We compare a composite intervention (comprising an implementation intention task, water conservation information, and shower timer) to a control condition. In a MoC exposure group we conducted the intervention 1–2 months after the start of their first year of university, while in the non-MoC group we conducted the intervention ~5–6 months after the start of their first year of university. We evaluated four hypotheses.

Hypothesis 1: In line with previous research (Holland et al., 2006; Rise et al., 2003; Bamberg, 2000; Walton and Hume, 2011), we anticipate that the composite intervention will lead to positive changes in water consumption (reduced shower time, increased water-saving behaviors) compared to the control condition.

Hypothesis 2: In line with previous research (e.g., Bell et al., 2016; Armitage and Arden, 2008) we anticipate that the intervention will be more effective for participants who have higher readiness to change concerning saving water.

Hypothesis 3: Consistent with Verplanken and Orbell (2003), we anticipate that the intervention will be more effective for participants whose water behavior is less habitual.

Hypothesis 4: In line with previous research on the Habit Discontinuity Hypothesis (Verplanken and Roy, 2016), we expect the intervention to be more efficacious for those students who had started university more recently (1–2 months before) than for those who had started university less recently (5 to 6 months before).

Methods

Design and participants

We used a $2 \times 2 \times 3$ mixed-factorial design: 2 (*Intervention*: intervention or control) $\times$ 2 (*MoC*: 1–2 months or 5–6 months) $\times$ 3 (*Time*: baseline, 7-days and 21-days). Student participants were sampled from university campus residential accommodation (residences) on a purpose-built university campus in a suburb of a city in the United Kingdom. The intervention was administered at baseline. Two dependent variables (*shower time* and *water-saving behavior*) and two further independent variables (*readiness to change* and *habit-strength*) were measured by questionnaire; a third dependent variable, (residential) *water usage* was recorded across a two-month study period.

Assignment to intervention/control conditions was randomized at the residential level, across 55 different buildings: 45 small buildings (each small building housing ~11 to 13 students) and 10 large buildings (each large building housing between 34 and 303 students; large building $M = 133.2$, $SD = 70.53$). The intervention was assigned to 20 small buildings and 6 large buildings. MoC groups (1–2 months and 5–6 months) were recruited in separate waves to ensure that all participants were from the same student cohort. The first wave (1–2 months group) was recruited from the small residences and the second wave (5–6 months group) was recruited in the large residences; thus the two samples were independent.¹ During recruitment, participants were informed that the study aimed to explore the impacts of the cost of living on lifestyle. Our initial sample across both waves consisted of 186 first year university student participants: age range 18–22 ($M = 18.7$); 48.4% female; 47.3% male; 1.6% non-binary/third gender; 2.7% preferred not to say. The questionnaire on day-7 was completed by 103 participants (55.4%) and the questionnaire on day-21 by 94 participants (50.5%).

Materials, measures and variables

Intervention

The composite intervention consisted of: (1) water-saving information; (2) implementation intention task; (3) a shower timer and instructions. Information concerned water-scarcity and the importance of individual water-use reduction, including eight behaviors (hints/tips) for water-saving. Behaviors were drawn from content analysis of current water-saving in the top six websites found from Google search-engine results (searching “Water saving hints and tips UK”). The implementation intention task (Bell et al., 2016) asked participants to reflect on the eight behaviors they had read, then participants were asked to select four of these behaviors and formulate “if/then” statements for these using a pro-forma table. Several examples were given for guidance. Finally, instructions were given concerning the shower timer. This encouraged them to reduce shower time to under 4 min, and provided brief operating instructions: the shower timer was a sand-timer intended for use in the shower which had a duration of ~4-min.

Filler-task

Participants in the control condition did not receive the composite intervention. Instead, they completed a reading comprehension filler-task (e.g., Mometrix, 2023). Participants were

asked to read a paragraph of rules for a word-game, and it was stated that they may be asked to play this game with other participants later in the study. There followed four multiple-choice questions about the details in the text. The task's subject matter was a geographical word game and so was not related to water-saving or to sustainability.

Shower time

A single open-answer question read: “How long, on average do you spend in the shower? Please write your answer in minutes in the box below. This can be a rough guess”. We excluded three outlying participants from shower time analyses.²

Water-saving behaviors

These were measured with an eight-item self-report scale, adapted from previous research on energy-saving behavior by Hafner et al. (2020). Water-saving behaviors were identified in the same content analysis used to produce the informational component of the intervention. We asked the question “thinking about the last 2 weeks, how often have you taken the following actions”, with five answer options [“never” (1), “very rarely” (2), “sometimes” (3), “often” (4) and “always” (5)] and eight items related to different water-saving behaviors. Items included, for example, “When boiling the kettle I have only filled it with as much water as I need” and “When washing fruit and vegetables I have used a bowl of cold water rather than continuously running the tap”. Seven of eight items were scaled using a mean average across all item scores (Cronbach's $\alpha = 0.66$); one (tooth brushing) was excluded as it consistently reduced reliability across all three time points. To reduce the salience of water-use and so discourage demand effects (Orne, 1962), these items were randomized within a block of 16 items, with the other eight items reflecting unrelated lifestyle behaviors, such as “I have exercised or played sports” and “I have spent time in voluntary work, e.g., befriending or answering a help-line” (e.g., Hagggar et al., 2023). The Supplementary material contains the complete questionnaire, including all 16 items.

Habit strength

Participants were asked to rate their agreement with each of four statements, on a five-point scale from “strongly disagree” (1) to “strongly agree” (5). The four statements were those from the Self-Report Behavioral Automaticity Index (SRBAI: Gardner et al., 2012), the purpose of which is to measure the automaticity of a behavior; automaticity is a necessary condition of habit, and stronger habits are more automatic (Verplanken and Orbell, 2003). Each statement reflected domestic water use, beginning with the phrase “using water in my home is something I do...”, e.g., “using water in my home is something I do automatically” and “using water in my home is something I do without having to consciously

¹ MoC varied systematically rather than being randomised across buildings because first-wave recruitment was initially targeted only at small buildings, due to these buildings containing water-meters for each set of 11–13 students living together as a single household. However, we faced difficulty in recruiting sufficient participants to make appropriate analyses and so decided, in wave 2, to broaden our recruitment to larger residences, where the potential for recruitment was greater, but water meter data was only available for buildings rather than for each household within the building.

² Data points were excluded if they were either over the third quartile+(3*Interquartile range) or under the first quartile-(3*Interquartile range). The outlying shower times were 45 min, 30 min, and 25 min.

remember". Scores for the four statements were scaled using a mean average across all item scores (Cronbach's $\alpha = 0.80$), however this variable had marked left skew (Median = 4), so, for analysis, we re-categorized scores into a two-level factor: "strong" (>4 ; $n = 83$) or "weak" (≤ 4 ; $n = 102$).

Readiness to change

This was measured using a single question with an ordinal scale of five response options, adapted from Bell et al. (2016). For analysis, due to small and uneven sub-sample sizes, we re-categorized scores into three ordinal categories: *low* ("I currently do not try to save water and I am not thinking about starting" (1) or "I currently do not try to save water but I am thinking about starting" (2); $n = 55$), *medium* ("I currently try to save water but not on a regular basis" (3); $n = 83$), or *high* ("I currently try to save water but have only done so recently/in the last 6 months" (4) or "I currently try to save water and I have done so for a long time/longer than 6 months" (5); $n = 47$).

Demographics

The participants completed questions about their age, gender, and place of residence (in the baseline questionnaire only). These and all other questionnaire items are included in the [Supplementary material](#).

Water meter variables

Water meter readings for the study period were made available to us and were in cubic meters (m^3). Data was not available for all buildings but was available at 24 small buildings (12 assigned to the intervention) and 8 large buildings (5 assigned to the intervention). To facilitate comparability between different buildings, and better allow for possible confounding between the MoC groups and building sizes, small building readings were aggregated into one of two data-points: small buildings in the intervention condition and small buildings in the control condition. The maximum number of residents was derived from existing records (Universities UK, 2024) and used as an explanatory variable. We reasoned that the impact of the intervention upon this water usage would be negatively moderated by the number (or proportion) of study participants in a residence (i.e., varying exposure to the intervention), hence we also included the percentage of participants in a residence (based on maximum occupancy) and the interaction (product) variable for this percentage and participating in a building whose participants received the intervention as explanatory variables.

Procedure

We received ethical approval from the Ethics Committee at the University's Department of Psychology (Reference number: 23-016) before launching the study. University student volunteers from the "climate champions" programme implemented initial recruitment in-person, visiting student residences on campus to this purpose. Those recruited in residences assigned to the

intervention condition were given a shower-timer and asked to scan a QR-code that hyperlinked to an online questionnaire in which the intervention was embedded. Those recruited in control residences were not given a shower-timer and were asked to scan a different QR-code that hyperlinked to an online questionnaire identical to that used in the intervention condition, except that a filler-task was substituted for the intervention. The questionnaire began with a briefing page concerning the study and the terms of participation and data retention. Here, it was stated that: "the project aims to explore engagement with different lifestyle behaviors and impacts of the cost of living". Participants then gave their informed consent, completed either the intervention material or the filler task, and then answered questionnaire questions. Follow-up questionnaires were sent to participants 7-days later and 21-days later. These were identical, except that the 21-days questionnaire ended with a written debrief covering the aims and purpose of the study and thanking participants for their participation. All participants were remunerated and received additional remuneration (prize draw entry) if they had completed all three questionnaires. Recruitment took place in two waves. The procedure was identical in each wave. Participants in the 1–2-month group (first wave) were recruited from October to December 2023 and water meter readings were taken before the study, in October, and on 13th November.³ The second wave (when the student cohort had been resident at the university for ~5–6 months) were recruited from February to April 2024, and water meter readings were taken in February and April.

Data analysis plan

Data was cleaned, including the removal of outliers (defined as greater than the third quartile plus three times the interquartile range or less than the first quartile minus three times the interquartile range). Analyses were conducted using SPSS version 29. Hypothesis tests using survey data were made using mixed Analysis of Variance (ANOVA) models. To conserve statistical power, given our relatively small sample size, several models tested fewer factors and/or fewer levels than described in our study design. All dependent variable measures deviated from the normal distribution. Hence, aligned rank transformed (ART) data was used through the ARTool software (Wobbrock et al., 2011; Elkin et al., 2021).⁴ As a repeated-measures assumption of sphericity was rarely met, the Greenhouse-Geisser correction was used (Blanca et al., 2023). Planned comparisons were t tests on ART data with Bonferroni correction applied for multiple comparisons. An analysis of water usage at the residential level was made using multiple linear regression.

³ The final reading is slightly earlier due to the Christmas holidays, during which most students return to their family homes and, hence, water usage in residences is lower.

⁴ This necessitates aligning and ranking data for each F test rather than each ANOVA.

Results

Baseline descriptive statistics

Descriptive statistics for measured variables (Table 1) show mean averages for water-saving behavior and readiness to change to be close to the scale mid-point (3), whereas the mean average for water-saving habit strength is somewhat greater than the scale mid-point. Skewness and kurtosis statistics indicate (on a $Z \pm 3.29$ criterion) that: (a) age and shower time are both right-skewed and leptokurtic; (b) habit strength is left-skewed (Mishra et al., 2019). Descriptively, intervention participants report somewhat shorter showers, $M(SD) = 9.0 (5.35)$ than control participants, $M(SD) = 10.3 (5.84)$ and somewhat more water-saving behavior, $M(SD) = 2.7 (0.74)$, than control participants, $M(SD) = 2.5 (0.76)$, at baseline. Mann-Whiney U-Tests were made to assess these differences, as well as to compare habit strength and readiness to change between groups at baseline, however differences were not statistically significant, either for shower-time, $U(Z) = 3782.5 (1.37)$, $p = 0.171$, water-saving behavior, $U(Z) = 3,619.0 (1.81)$, $p = 0.071$, habit strength, $U(Z) = 3,755.0 (1.66)$, $p = 0.097$, or readiness to change, $U(Z) = 4,272.5 (0.01)$, $p = 0.994$.

Intervention efficacy

Shower time

A 2 (Intervention: Intervention or Control) $\times$ 3 (Time: Baseline, 7-day, and 21-day) mixed ANOVA showed a significant main effect of time, $F_{(1.58,139.38)} = 15.50$, $p < 0.001$, $\eta^2 = 0.150$, but the main effect of intervention and the interaction effect were not statistically significant. Descriptive comparison (Figure 1) showed shower time to be descriptively longer at baseline, $M(SD) = 9.43 (4.99)$, than at either 7-days, $M(SD) = 8.66 (4.41)$, or 21-days, $M(SD) = 8.07 (4.43)$.

Water-saving behavior

A 2 (Intervention: Intervention or Control) $\times$ 3 (Time: Baseline, 7-day, and 21-day) mixed ANOVA showed a significant main effect of time, $F_{(1.805,164.23)} = 12.63$, $p < 0.001$, $\eta^2 = 0.122$, and a significant interaction effect, $F_{(1.83,166.05)} = 4.35$, $p = 0.017$, $\eta^2 = 0.046$, but the main effect of intervention was not statistically significant, $F_{(1,91)} = 1.86$, $p = 0.176$. Descriptive comparison (Figure 2) suggested that baseline water-saving was less, $M(SD) = 2.60 (0.706)$, than either 7-day water-saving, $M(SD) = 2.82 (0.729)$, or 21-day water-saving, $M(SD) = 2.86 (0.760)$. Planned contrasts showed that intervention participants increased water-saving behavior between baseline and day-7, $M = +0.35$, $t_{(43)} = 3.09$, $p < 0.01$, and between baseline and day-21, $M = +0.45$, $t_{(43)} = 4.16$, $p < 0.001$, but the water-saving of control participants did not show statistically significant changes.

Water usage

On average, the 10 residences used 1,000.7 m³ of water ($SD = 655.18$ m³) over the test periods and housed 166.6 residents ($SD = 72.89$), ranging between 99 and 303 residents, of whom

between 10 and 33, $M(SD) = 19.0 (8.88)$, participated in the study in each residence. Table 2 shows the results of a multiple linear regression of residential water usage on maximum number of residents, the number of study participants as a percentage of the maximum number of residents, and whether participating residents received the composite intervention (1) or not (0). The model fit was high, $R^2 \text{ adj.} = 0.955$, likely due to close correlation between maximum residency and water usage, $r = 0.957$, $p < 0.001$. While the intervention effect was not statistically significant, the proportion of residents participating showed a statistically significant negative association with water usage, indicating that the more people participated in the study the less water was used during the study period, irrespective of intervention or control conditions.

Summary

Hypothesis 1 stated that “the composite intervention will lead to positive changes in water consumption (reduced shower time, increased water-saving behaviors) compared to the control condition”. We found evidence that the intervention led to increases in water-saving behaviors, but we did not find evidence that the intervention led to reduced shower time or lower residential water usage. However, overall, we found evidence that positive changes in water consumption did occur across time: shower times reduced, water-saving behavior increased, and residential water-usage was smaller when more study-participants were in residence.

Readiness to change and existing habits

Shower time

A 3 (Readiness to change: low, medium or high) $\times$ 3 (Time: Baseline, 7-day and 21-day) mixed ANOVA using the intervention group subset only ($n = 43$) showed a significant main effect for time, $F_{(1.44,57.49)} = 4.79$, $p = 0.021$, $\eta^2 = 0.107$, but no significant main effect of readiness to change or interaction effect. A 2 (Habit Strength: low or high) $\times$ 3 (Time: Baseline, 7-day and 21-day) mixed ANOVA using the intervention group subset only ($n = 43$) showed a significant main effect of time, $F_{(1.48,60.67)} = 4.32$, $p = 0.027$, $\eta^2 = 0.095$, but no significant main effect of habit strength or a significant interaction.

Water-saving behavior

A 3 (Readiness to change: low, medium or high) $\times$ 3 (Time: Baseline, 7-day and 21-day) mixed ANOVA using the intervention group subset only ($n = 44$) showed significant main effects of time, $F_{(1.55,63.54)} = 12.74$, $p < 0.001$, $\eta^2 = 0.237$ and of readiness to change, $F_{(2,41)} = 4.39$, $p = 0.019$, $\eta^2 = 0.176$. However, the interaction effect was not statistically significant. Descriptively, water-saving behavior was greater with greater readiness of change, from a mean average score of 2.58 (low) to 2.87 (medium) and to 3.38 (high). Planned comparisons for behavior changes following baseline within each level of readiness to change showed only one statistically significant difference (after Bonferroni correction): those with low readiness to change showed greater water-saving behavior after 21 days, $M = +0.56$, $t_{(14)} = 3.10$, $p = 0.004$. A 2

TABLE 1 Baseline descriptive statistics.

	<i>N</i>	Minimum	Maximum	<i>M</i> (<i>SD</i>)	Skewness (<i>SE</i>)	Kurtosis (<i>SE</i>)
Age	186	18	22	18.71 (0.826)	1.34 (0.178)	2.53 (0.355)
Shower time	185	2	45	9.95 (6.031)	2.14 (0.179)	7.23 (0.355)
Water-saving behavior	185	1	5	2.56 (0.753)	0.46 (0.179)	−0.01 (0.355)
Habit strength	185	1.75	5	4.04 (0.749)	−0.67 (0.179)	0.10 (0.355)
Readiness to change	185	1	5	3.01 (1.163)	0.18 (0.179)	−0.49 (0.355)

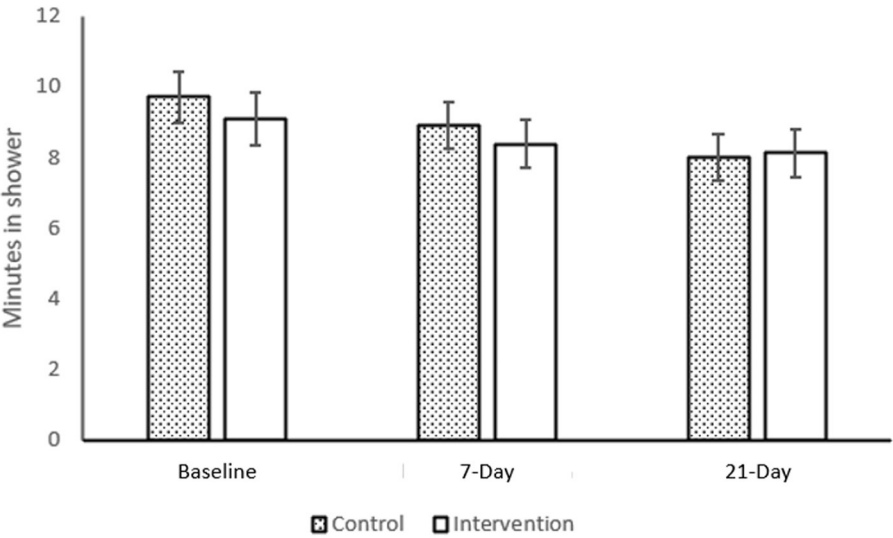


FIGURE 1 Intervention and shower time. Control *n* = 47, Intervention *N* = 43. Error bars show 1SE.

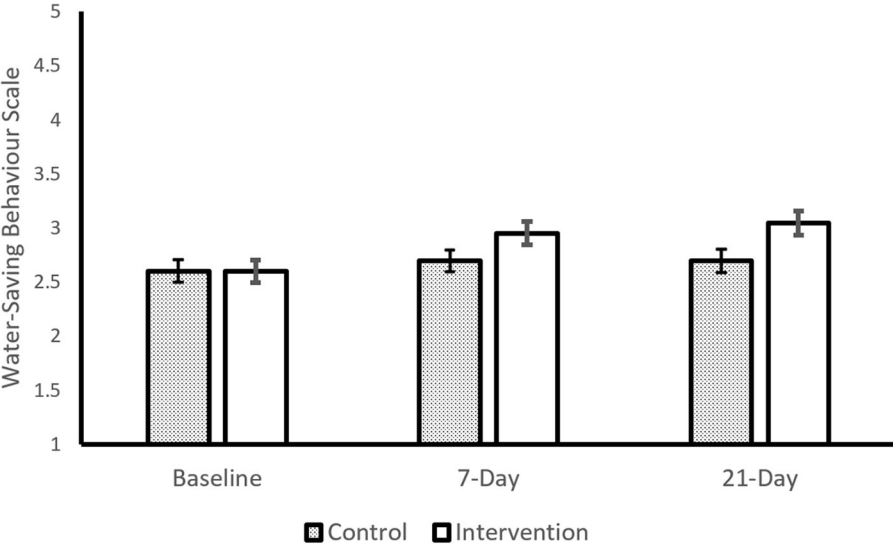


FIGURE 2 Intervention and water-saving behavior. Control *n* = 49, Intervention *N* = 44. Error bars show 1SE. Water saving behavior scales ranges between 1 and 5.

TABLE 2 Residential water usage regressed on residents, experimental condition and estimated percentage of residents participating.

Variable	B (SE)	Beta	t	p	95% CI	
					Low	High
Intercept	81.18 (209.193)		0.39	0.71	−430.7	593.1
Residents	7.56 (0.707)	0.84	10.69	<0.001	5.83	9.29
Experiment	77.41 (89.731)	0.06	0.86	0.42	−142.2	297.0
%Participants	−31.38 (9.645)	−0.26	−3.25	0.02	−54.98	−7.78

N = 10. “Residents” is maximum number of residents, i.e., bedrooms. “Experiment” is participation in intervention (1) or non-intervention (0) condition. “%Participants” is the number of participants in the residence divided into Residents. R^2 adj. = 0.955. Analysis expressing “%Participants” as a count variable yields similar (i.e., statistically significant) results: $B(SE) = -17.05$ (5.624), $p < 0.05$, 95%CI [-30.8, -3.29]. Entering an Experiment*%Participants interaction (product) variable neither explains additional variance nor reaches statistical significance as an explanatory variable. Explanatory variables are not statistically significantly correlated: Residents with %Participants ($r = -0.44$, $p = 0.204$), Residents with Experiment ($r = 0.05$, $p = 0.894$), or %Participants with Experiment ($r = 0.048$, $p = 0.894$).

(Habit Strength: low or high) $\times$ 3 (Time: Baseline, 7-day and 21-day) mixed ANOVA using the intervention group subset only ($n = 44$) showed a significant main effect of time, $F_{(1.56,64.14)} = 13.79$, $p < 0.001$, $\eta^2 = 0.252$, however neither the main effect of habit strength nor the interaction effect was statistically significant.

Summary

Hypothesis 2 stated that “In line with previous research (e.g., Bell et al., 2016; Armitage and Arden, 2008) we anticipate that the intervention will be more effective for participants who have higher readiness to change concerning saving water”. We found no evidence that readiness to change affected changes in water-saving behavior or shower time in the intervention group. Hypothesis 3 stated that: “Consistent with Verplanken and Orbell (2003), we anticipate that the intervention will be more effective for participants whose water behavior is less habitual”. We found no evidence that habit strength affected changes in water-saving behavior or shower time in the intervention group. Hence, we found no evidence to support either Hypothesis 2 or Hypothesis 3.

Starting university as a moment of change

Shower time

A 2 (Intervention: Intervention or Control) $\times$ 2 (MoC: 1–2 months or 5–6 months) $\times$ 2 (Time: Baseline and 21-day) mixed ANOVA showed a significant main effect of time, $F_{(1,86)} = 25.06$, $p < 0.001$, $\eta^2 = 0.226$ and a significant time $\times$ MoC interaction effect, $F_{(1,86)} = 8.35$, $p = 0.005$, $\eta^2 = 0.088$, however, other effects, including the three-way interaction effect, were not statistically significant. The pattern of change is described in Figure 3. Planned comparisons showed that with the intervention shower time reduced by around two and a half minutes over 21 days in the 5–6-month group, $M = -2.48$, $t_{(28)} = 3.06$, $p < 0.01$, and without the intervention shower time reduced by around 1 min over 21 days in the 1–2-month group, $t_{(27)} = 2.49$, $p < 0.01$. The observed reductions in the 5–6-month group reduced average shower time from a higher level (of around 10 min) to times more comparable to the 1–2-month group (of around 8 min).

Water-saving behavior

A 2 (Intervention: Intervention or Control) $\times$ 2 (MoC: 1–2 months or 5–6 months) $\times$ 2 (Time: Baseline and 21-day) mixed ANOVA showed a statistically significant main effect of time, $F_{(1,89)} = 15.32$, $p < 0.001$, $\eta^2 = 0.147$, and a significant time-intervention interaction, $F_{(1,89)} = 6.25$, $p = 0.014$, $\eta^2 = 0.066$. However, other effects, including the 3-way interaction effect, were not statistically significant. Descriptive patterns are shown in Figure 4.

Summary

Hypothesis 4 stated that “the intervention would be more efficacious for those students who had started university 1–2 months previously than for those who had started 5–6 months previously”. We found no clear evidence that the intervention was more efficacious in the 1–2-month group than in the 5–6-month group. For water-saving behavior, we found no evidence of any differences relating to MoC. For shower time, we found no evidence that the intervention was more effective in either MoC condition, but our results showed that the greatest reductions occurred in the 1–2-month group that did not receive the intervention and the 5–6-month group that did.

Overall summary

Our analysis supports the following findings. (1) Across 21-days, both outcome variables improved: water-saving behavior increased, shower-time decreased. (2) Residential water-use across 21-days was negatively associated with the number of study participants living in the residence. (3) The intervention increased water-saving behavior. (4) This increase was *not* affected by levels of either readiness to change or habit strength. (5) The intervention did *not* reduce shower time. (6) No intervention effect on shower time was evident at different levels of either readiness to change or habit strength. (7) At all three timepoints, those with greater readiness to change engaged in more water-saving behavior. (8) Across 21-days, the effect of the intervention upon water-saving behavior and shower time were the same for those who experienced a MoC (the 1–2-month group) and for those who did not (the 5–6-month group). (9) However, irrespective of the intervention, the non-MoC (5–6-month) group showed greater reductions in shower time across 21-days than did the MoC (1–2-month) group.

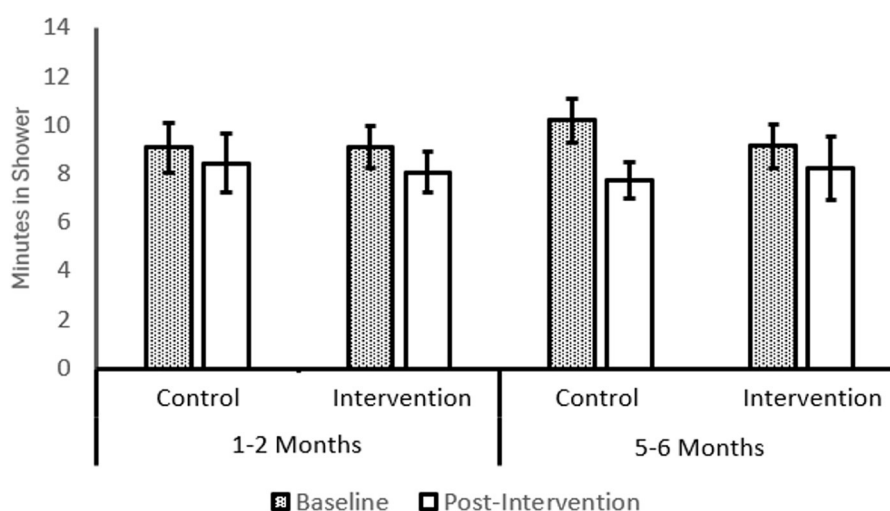


FIGURE 3

Shower Time with intervention and moment of change. Post-intervention period is 21-days. MoC is 1–2 months after starting university. Non-MoC is 5–6 months after starting university. MoC control $N = 20$; MoC Experimental $N = 29$; Non-MoC control $N = 27$; Non-MoC experimental $N = 14$. Error bars show 1SE.

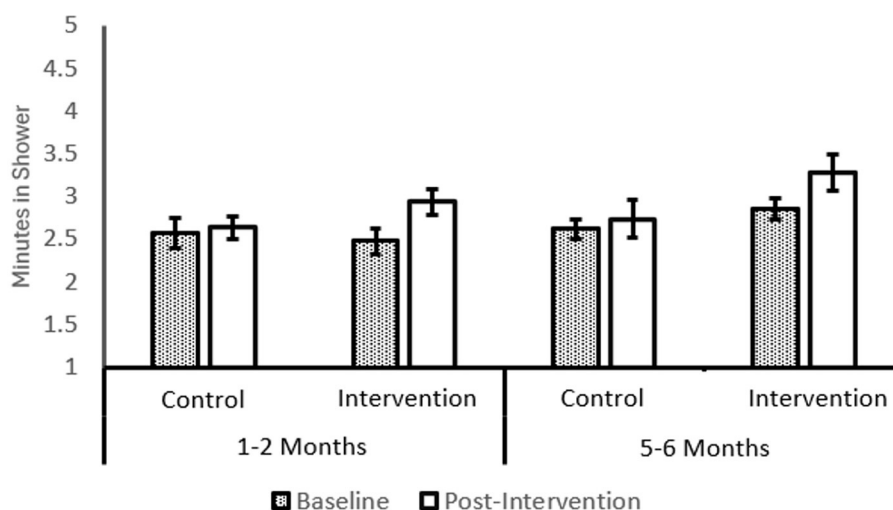


FIGURE 4

Water Saving Behavior with Intervention and Moment of Change. Post-Intervention period is 21-days. MoC control $N = 20$; MoC Experimental $N = 29$; Non-MoC control $N = 30$; Non-MoC experimental $N = 14$. Error bars show 1SE. Water Saving Behavior Scales ranges between 1 and 5.

Discussion

Water conservation is a key element in mitigating the effects of global climate change. While demand for water increases, its supply becomes increasingly difficult, even in temperate regions (Environment Agency, 2020). A key response is to reduce demand, particularly through domestic water practices, such as taking shorter showers and conserving water (DEFRA, 2023). However, water-use behaviors can become ingrained habits (Garcia-Valiñas et al., 2014; Gregory and Leo, 2003), and as such difficult to change (Verplanken and Aarts, 1999). This article reports the results of a longitudinal survey-based experiment the aim of which was to study the water use behavior of new university students, on the

premise that this is an optimal moment to affect behavioral change (Borman et al., 2018; Hayes et al., 2019).

Moments of Change (MoCs), such as moving house and beginning university, have been hypothesized to be ‘windows of opportunity’ during which behavior changes are more likely to occur (Verplanken et al., 2018). They have the potential to distance us from the contextual cues that trigger habitual responses automatically, leading to deliberate, informed actions becoming more likely (Verplanken and Aarts, 1999). While several studies have provided evidence in support of this account (e.g., Verplanken and Roy, 2016; Verplanken et al., 2018), important gaps remain in our understanding of moments of change, and the purpose of our study was to consider three such gaps. First, how the likelihood

of behavioral change is affected by a composite intervention incorporating implementation intentions. To our knowledge, this is the first study to try to use implementation intentions to affect domestic water-use behavior. Here, we found that the intervention increased self-reported water-saving behavior but did not change shower time or residential water usage. Contrary to our expectation, we found evidence to suggest improvements in water conservation behavior irrespective of whether participants received the intervention or not. Second, we considered how differences in readiness to change and the strength of existing habits each affect the likelihood of change. Here, we found that the intervention was no more effective with greater readiness to change or with weaker existing habits. Third, we considered how the recency of the change event may make participants more or less susceptible to an intervention. Here, we found the intervention was no more effective for participants with a recent (1–2 months after starting at university) than an earlier change event (5–6 months after starting at university).

Our composite behavior-change intervention consisted of information on water conservation (cf. Whitmarsh et al., 2021), an implementation intention formation task (Bell et al., 2016), and performance feedback monitoring in the form of a shower-timer (e.g., Haggard et al., 2023). Control participants completed a reading comprehension filler task instead. Implementation intentions have been shown to be effective in changing habitual behavior (Gollwitzer and Oettingen, 2020) and so may be especially effective during moments of change, when habits are hypothesized to weaken (Verplanken et al., 2018). Additionally, composite interventions, in general, are thought to be more effective than interventions with only one element (Osbaldiston and Schott, 2012). We found evidence that *water-saving behavior* increased with the intervention (compared to the control) but shower-time *specifically*, and residential water-usage, did not differ between intervention and control conditions. This suggests that the intervention may have made participants more conscious of water-saving behaviors and more likely to engage in some of these. However, our findings are consistent with shower-time maintenance being an unpopular choice and/or difficult to implement in practice. Changing behavior to save water is only as effective in saving water as the behaviors that are changed and, on average, showering is accountable for the highest proportion of domestic water use, making up around 34% of domestic water usage (Waterwise, 2024). To the extent that showering behavior was not affected, our intervention may have had less overall influence upon overall water usage, and to the extent that it was the proportional effect will diminish shower volumes with decreasing shower time.

Stages of change theories of behavior change, such as the transtheoretical model (Prochaska and DiClemente, 1983), hypothesize that behavior change moves through discrete stages, each marking a progression toward behavior change. Hence, we hypothesized that participants with greater readiness to change (Bell et al., 2016), those in later stages, would be more likely to change than those with less readiness to change, those in earlier stages. While we found that, overall, those with higher readiness to change reported more water-saving behavior than those with lower readiness to change, this may reflect associations between

readiness to change and behavior change motivations (e.g., pro-environmental orientation) and so may be explained as these individuals engaging in more water-saving from the outset. Yet, we found no evidence that readiness to change was related to water saving changes over the course of the experiment and/or with the intervention, implying that those with more readiness to change were as likely to increase their water saving during the study period as those with less readiness to change. This seems contrary to the way in which readiness-to-change has been found to affect implementation intention success (Bell et al., 2016; Armitage and Arden, 2008), so one implication is that the implementation intention element was not as effective as information and/or feedback elements. However, it is also worth considering that stages of change may be most appropriate to describe lengthy, effortful and deliberative process of behavioral change, and it is possible that water-saving behaviors showed rapid progress from contemplation to action, making readiness to change less relevant. Indeed, from a practical perspective, these findings seem to exclude the concern that first year university students may be unresponsive to the intervention due to being unready for change in their water-saving behaviors.

We hypothesized that the composite intervention would be more effective amongst participants with weaker water-use habits, because weaker habits may be most easily broken in comparison to strong habits, these being perhaps more generalized or ingrained (Verplanken and Aarts, 1999). We could not confirm this through our results. Likewise, we failed to confirm any difference in water use behavior between those with stronger and weaker habits, such as might be expected through the close relationship between habit strength and repeated behavior in context (Carden and Wood, 2018), namely that habits are learned and strengthened through repeated behavior, so using water habitually is likely the result of engaging in water-use behaviors, such as showering for longer. Having found no evidence to support our hypothesis that habits would moderate the efficacy of the intervention, one possibility is that the MoC, through habit discontinuity, weakened existing habits, making the strength of existing habit *less* important to the success of the intervention (Verplanken et al., 2018), but further investigation is warranted to show that this can be replicated.

While some researchers have suggested interventions as more effective within three months of a moment of change event (such as starting university), others consider enhanced efficacy up to 6-months after the event to be a possibility; hence we investigated interval periods of 1–2 month and 5–6 month between participants. We hypothesized that 1–2-month participants, for whom the MoC was more recent, would be more likely to respond to the water conservation intervention. We found no evidence to support this hypothesis, either for shower time changes or water-saving behavior changes. However, these analyses did involve evaluation of three-way interaction effects (between group (1–2 months or 5–6 months), intervention, and time) using relatively small samples, so it is possible that these results are type-II errors, particularly if the underlying effect is relatively weak, as has been indicated for habit discontinuity engendered sustainability (Verplanken and Roy, 2016). Another possibility is that the intervention is as effective at both timepoints and that it may be no less effective for an extended period, perhaps even up to 12-months (Thomas et al.,

2016). Additionally, one of our findings suggests the presence of a boundary condition: shower time (irrespective of intervention) only showed reductions for those who participated 5–6 months after starting university, raising the possibility that 1–2 months may be too soon after the event itself, where the challenges of adjusting to a new environment may limit the possibilities for enacting behavioral change (Burningham and Venn, 2020). In the context of the academic year, participants at the start of the university, at 1–2 months, may have felt oversaturated with new information and activities, compared to the participants 5–6 months later, who were in the full swing of their academic studies. Therefore, differences in the structure of academic activities over time, or in how students responded to these differences, may be reflected in our results. However, it is also worth mentioning that (1) the groups participated at different times-of-year (October to December and February to April, respectively) and (2) the observed reduction was more consistent with an adjustment from a longer shower-time of 10 minutes to a normal shower-time of 8 minutes (cf. Haggard et al., 2023). Together, this raises the possibility that (over the winter) students began taking longer showers for their thermal comfort and are moving back to what is a normal shower-length for that time of year, rather than of making beneficial reductions to levels below the current normal.

Beyond the intervention, we found evidence that participants (irrespective of intervention or control participation) reduced their shower times, increased their water saving and reduced residential water usage. These findings are mutually supportive: it is less plausible that both subjective and objective measures would differ by chance, and the comparison of participants to non-participants (i.e., maximum residential occupancy) in the objective measure analysis raises the possibility that changes may be greater for *participants* compared to *non-participants*, and not (for example) merely a manifestation of contextual changes, such as public attitudes to water saving. Moreover, as our design assigned participants to condition at the residential level, this tends to exclude the possibility that random assignment might have been compromised through information-sharing or mutual use of shower-timers within residences. This leaves the possibility of the questionnaires functioning as an intervention. First, completing the questionnaires (containing questions about personal water usage) may have increased participant-awareness of these behaviors, prompting behavioral changes (cf. Wolfstenholme et al., 2020). This would tend to reflect informational and feedback components: water-saving behavior questions were symmetric with the hints/tips provided in the intervention and so may have conveyed similar information, and the act of reporting behavioral frequencies on days one and seven may have functioned as a minimal type of monitoring. Second, although participants were told during recruitment that the study aimed to explore the impacts of the cost of living on behavior change, they may have inferred that this study focused on water from the fact that half of the lifestyle questions and all of the habit questions were water-related. This may have caused demand characteristics, leading to reduced water usage to meet researcher expectations, which were inferred from the content of the questionnaires alone, or the manner of recruitment (Orne, 1962). This may account for the general trend in our

findings whereby dependent variables showed improvement in both intervention and control groups. However, establishing effective controls in field research is also potentially limited with participants in similar social networks potentially discussed the study. These limitations, while problematic for research, are less problematic for practitioners, for whom general diffusion of water conservation is an objective. It is also important to reiterate that only intervention participants were exposed to practical water-saving information and asked to make if-then implementation plans.

This study had several important limitations. Theoretically, two recency conditions (1–2 months or 5–6 months following starting university) does not include a strong control group for testing the efficacy of starting university as an MoC or habit discontinuity, such as a comparison to a time-period before starting university, but this is not a salient limitation for studies testing the enhanced efficacy of concurrent interventions to change behavior (e.g., Verplanken and Roy, 2016). Practically, we encountered recruitment problems during the study, leading to relatively small sample sizes and prompting adjustments to recruitment and statistical analysis. Self-report measures of behavior are subject to biases, particularly to social desirability (Veseley and Klöckner, 2020). One way to allow for this is through collecting objective data for comparison. We made some use of available objective data, and this objective data was likely accurate (residence water use was closely correlated with the maximum occupancy of residences). However, our objective data measured the water use of larger buildings, rather than of individual students. Hence, each data-point was aggregated (across hundreds of individuals) and so does not capture the detail of changes in water-use of each individual, or of smaller groups such as flats or corridors within buildings. Hence, while each measurement may be quite accurate, this aggregation makes data less accurate in reflecting the changes in water use of individuals or smaller groups. However, when considered as data reflecting water-use within buildings, relatively few buildings were sampled (amounting to ten data-points), increasing the possibility that the relationship we found between participation in the study and building-level water use occurred by chance. Hence, a fruitful avenue for further work would be conceptual replication implementing additional measurements, such as by metering high water-usage devices in communal areas of residences (e.g., showers) to ensure data at a less aggregate level, albeit limited to water use from particular behaviors. A further limitation in our design was in assessing baseline levels of measured variables in the baseline questionnaire only after the intervention (or filler task) had been completed. This leaves open the possibility that the intervention task may have, to some extent, primed or otherwise influenced answers to later questions, confounding the effects of time and intervention. However, if this was an important biasing factor, then we'd expect group differences on measured variables at baseline, and no such differences were evident.

Theoretically, our results provide modest support for a MoC or habit discontinuity account of changes taking place in water saving when an intervention to change behavior is used shortly after students begin university. This is because we found only modest change in behavior attributable to the intervention and no clear differences attributable to the timing of the intervention.

However, our findings are consistent with the idea that going to university may be initially, within 1–2 months, an *inopportune* moment to undertake such personal behavior changes (although further research is necessary to exclude the potential effects of seasonal variation in shower duration). This corresponds to the idea that some events, while they may involve changes in context and/or disruptions in existing habits that meet the criteria for moments of change, may, at the same time, also involve more immediate priorities, identity or role changes, lifestyle disruptions, or other demanding or stressful elements that tend to limit the extent to which a change is feasible rather than facilitate change (Burningham and Venn, 2020). This has been considered as a factor that might limit the effectiveness of interventions during moments of change, if the interventions are delivered during periods in the transition when people's attention is divided and they are correspondingly less receptive (Schäfer et al., 2012). Further research with respect to the context of life events could also offer insights into which events or stages (during moments of change) are disruptive of contextual cues while not being too stressful or demanding, thus clearing multiple barriers to successfully reforming unwanted behavioral habits.

For policy-makers concerned with achieving water use reductions, such as on a university campus, our results do not support a recommendation to intervene with students soon after their arrival, but to allow perhaps 5 months before attempting to raise awareness. While our results do not seem to support a thorough recommendation for use of the behavior change intervention techniques we employed (information, implementation intentions, and feedback), they were somewhat effective, and have proved effective techniques in changing different behaviors in the past (Osbaldiston and Schott, 2012). Hence, it remains an open possibility that these techniques may prove effective if they are enhanced or if some unknown impediment is overcome. In the present study, the intervention was text-based, and participants were trusted to put what they had read into practice for themselves, whereas greater involvement from the researcher team (e.g., through direct communication and monitoring) may provide social reinforcement. Psychologically, a commitment (e.g., a public declaration) can enhance adherence to a change attempt (Lokhorst et al., 2013) and to implementing the means to affect change, such as perhaps forming stronger implementation intentions at the outset. Also, factors that may have impeded the intervention exist. Perhaps the most important was motivation: while the information we provided was factual, with advice on reducing water use, such information may risk being too abstract, particularly given the meteorological climate of the UK, in which precipitation is abundant. While enhancing the intervention is one avenue, our results did raise the possibility that an elaborate intervention may be no less effective than merely asking participants to monitor their own actions as part of a scientific study. Unfortunately, such scientific monitoring may be intrusive when implemented at scale or beyond the ethical framework of research—it is possible that social marketing or awareness-raising campaigns may not inspire similar adherence. Hence, a comparable approach could be to collect and offer feedback digitally, such as by smart meter or smartphone application, to support long-term self-monitoring and open a channel for information provision and practical demonstration (Cominola et al., 2021).

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 humans were approved by the Psychology Research Ethics Committee, University of Bath. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

KM: Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. FR: Writing – original draft, Visualization, Investigation, Formal analysis. PH: Writing – review & editing, Writing – original draft, Visualization, Formal analysis. RH: Writing – review & editing, Supervision, Methodology, Conceptualization. AL: Writing – review & editing, Resources. LW: Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by the European Research Council as part of the MOCHA project [grant number 820235] and by the ESRC Center for Climate Change & Social Transformations (CAST); ES/S012257/1. Shower timers were provided by the University of Bath Climate Action Team.

Acknowledgments

The authors would like to thank the University of Bath Climate Action Team and each of the Climate Champions for their invaluable assistance and support on this project.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Author disclaimer

Kaloyan Mitev has now moved to the Joint Research Centre, European Commission; any of the views expressed in this paper do not represent the views of the European Commission.

References

- Aarts, H., Dijksterhuis, A., and Midden, C. (1999). To plan or not to plan? Goal achievement or interrupting the performance of mundane behaviors. *Eur. J. Soc. Psychol.*, 29, 971–979.
- Armitage, C. J., and Arden, M. A. (2008). How useful are the stages of change for targeting interventions? Randomised test of a brief intervention to reduce smoking. *Health Psychol.* 27, 789–798. doi: 10.1037/0278-6133.27.6.789
- Arnett, J. J. (2016). College students as emerging adults: the developmental implications of the college context. *Emerg. Adulth.* 4, 219–222. doi: 10.1177/2167696815587422
- Bamberg, S. (2000). The promotion of new behavior by forming an implementation intention: results of a field experiment in the domain of travel mode choice. *J. Appl. Soc. Psychol.* 30, 1903–1922. doi: 10.1111/j.1559-1816.2000.tb02474.x
- Bell, B., Toth, N., Little, L., and Smith, M. (2016). Planning to save the planet using an online intervention based on implementation intentions to change adolescent self-reported energy-saving behavior. *Environ. Behav.* 48, 1049–1072. doi: 10.1177/0013916515583550
- Beyers, W., Goossens, L., Vansant, I., and Moors, E. (2003). A structural model of autonomy in middle and late adolescence: connectedness, separation, detachment, and agency. *J. Youth Adolescence* 32, 351–365. doi: 10.1023/A:1024922031510
- Blanca, M. J., Arnau, J., García-Castro, F. J., Alarcón, R., and Bono, R. (2023). Repeated measures ANOVA and adjusted F-tests when sphericity is violated: which procedure is best? *Front. Psychol.* 14:1192453. doi: 10.3389/fpsyg.2023.1192453
- Bolton, P. (2024). “Higher education student numbers,” in *House of Commons Library*. Available at: <https://commonslibrary.parliament.uk/research-briefings/cbp-7857/> (accessed April 30, 2024).
- Borman, G. D., Grigg, J., Rozek, C. S., Hanselman, P., and Dewey, N. A. (2018). Self-affirmation effects are produced by school context, student engagement with the intervention, and time: Lessons from a district-wide implementation. *Psychol. Sci.* 29, 1773–1784. doi: 10.1177/0956797618784016
- Burningham, K., and Venn, S. (2020). Are lifecourse transitions opportunities for moving to more sustainable consumption? *J. Consum. Cult.* 20, 102–121. doi: 10.1177/1469540517729010
- Carden, L., and Wood, W. (2018). Habit formation and change. *Curr. Opin. Beh. Sci.* 20, 117–122. doi: 10.1016/j.cobeha.2017.12.009
- Cominola, A., Giuliani, M., Castelletti, A., Fraternali, P., Gonzalez, S., Herrero, J., et al. (2021). Long-term water conservation is fostered by smart meter-based feedback and digital user engagement. *NPJ Clean Water* 4:29. doi: 10.1038/s41545-021-00119-0
- Crippa, M., Oreggioni, G., Guizzardi, D., Muntean, M., Schaaf, E., Lo Vullo, E., et al. (2020). *Fossil CO2 and GHG Emissions of All World Countries – 2020 report*, EUR 30358 EN. (Luxemburg: Publication Office of the European Union).
- Dean, A. J., Kneebone, S., Tull, F., Lauren, N., and Smith, L. D. (2021). ‘Stickiness’ of water-saving behaviours: what factors influence whether behaviours are maintained or given up? *Resour. Conserv. Recy.* 169:105531. doi: 10.1016/j.resconrec.2021.105531
- DEFRA (2023). *Plan for Water: out Integrated Plan for Delivering Clean and Plentiful Water*. Available at: <https://www.gov.uk/government/publications/plan-for-water-our-integrated-plan-for-delivering-clean-and-plentiful-water/plan-for-water-our-integrated-plan-for-delivering-clean-and-plentiful-water> (accessed April 30, 2024).
- Drake, E. C., Sladek, M. R., and Doane, L. D. (2016). Daily cortisol activity, loneliness, and coping efficacy in late adolescence: a longitudinal study of the transition to college. *Int. J. Behav. Dev.* 40, 334–345. doi: 10.1177/0165025415581914
- Elkin, L. A., Kay, M., Higgins, J. J., and Wobbrock, J. O. (2021). “An aligned rank transform procedure for multifactor contrast tests,” in *The 34th Annual ACM Symposium on User Interface Software and Technology* (New York, NY: Association for Computing Machinery), 754–768. doi: 10.1145/3472749
- Environment Agency (2020). *Meeting Our Future Water Needs: a National Framework for Water Resources*. Available at: <https://www.gov.uk/government/publications/meeting-our-future-water-needs-a-national-framework-for-water-resources> (accessed April 30, 2024).
- Erikson, E. H. (1968). *Identity: Youth and Crisis*. New York, NY: WW Norton & Company.
- Finley, S. L., and Basu, N. B. (2020). Curbing the summer surge: permanent outdoor water use restrictions in humid and semiarid cities. *Water Resour. Res.* 56:e2019WR026466. doi: 10.1029/2019WR026466
- Fujii, S., and Garling, T. (2005). “Temporary structural change: a strategy to break car-use habit and promote public transport,” in *Traffic and Transport Psychology: Theory and Application*, ed. G. Underwood (Oxford, UK: Elsevier), 585–592.
- García-Valiñas, M. A., Athukorala, W., Wilson, C., Torgler, B., and Gifford, R. (2014). Nondiscretionary residential water use: the impact of habits and water-efficient technologies. *Aust. J. Agr. Resour. EC.* 58, 185–204. doi: 10.1111/1467-8489.12030
- Gardner, B. (2009). Modelling motivation and habit in stable travel mode contexts. *Transport Res. F-Traf.* 12, 68–76. doi: 10.1016/j.trf.2008.08.001
- Gardner, B., Abraham, C., Lally, P., and de Bruijn, G. J. (2012). Towards parsimony in habit measurement: Testing the convergent and predictive validity of an automaticity subscale of the Self-Report Habit Index. *Int. J. Behav. Nutr. Phys.* 9, 1–12. doi: 10.1186/1479-5868-9-102
- Gardner, B., and Lally, P. (2018). “Modelling habit formation and its determinants,” in *The Psychology of Habit: Theory, Mechanisms, Change, and Contexts*, ed. B. Verplanken (Cham, Switzerland: Springer) 207–229.
- Goette, L., Leong, C., and Qian, N. (2019). Motivating household water conservation: A field experiment in Singapore. *PLoS ONE* 14:e0211891. doi: 10.1371/journal.pone.0211891
- Gollwitzer, P. M., and Oettingen, G. (2020). “Implementation intentions” in *Encyclopedia of Behavioral Medicine*, eds M. Gellman and J. Turner (New York, NY: Springer), 1159–1164.
- Gregory, G. D., and Leo, M. D. (2003). Repeated behavior and environmental psychology: the role of personal involvement and habit formation in explaining water consumption. *J. Appl. Soc. Psychol.*, 33:6, 1261–1296. doi: 10.1111/j.1559-1816.2003.tb01949.x
- Grilli, G., and Curtis, J. (2021). Encouraging pro-environmental behaviours: a review of methods and approaches. *Renew. Sust. Energ. Rev.* 135:110039. doi: 10.1016/j.rser.2020.110039
- Hafner, R., Fuertes, A., Pahl, S., Jones, R., Gongolells, M., and Casals, M. (2020). Results and insight gained from applying the EnergyCat energy-saving serious game in UK social housing. *Int. J. Serious Games* 7, 27–48. doi: 10.17083/ijsg.v7i2.333
- Haggar, P., Whitmarsh, L., and Nash, N. (2023). A drop in the ocean? Fostering water-saving behavior and spillover through information provision and feedback. *Environ. Behav.* 55, 520–548. doi: 10.1177/00139165231201371
- Hand, M., Shove, E., and Southerton, D. (2005). Explaining showering: a discussion of the material, conventional, and temporal dimensions of practice. *Sociol. Res. Online* 10, 101–113. doi: 10.5153/sro.1100
- Hayes, L., Zinner, L., Wise, J., and Carton, J. (2019). Effects of a self-affirmation intervention on grades in middle school and first-year college students. *J. Artic. Support Null Hypoth.* 16:1.
- He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Li, J., et al. (2021). Future global urban water scarcity and potential solutions. *Nat. Commun.* 12:4667. doi: 10.1038/s41467-021-25026-3
- Holland, R. W., Aarts, H., and Langendam, D. (2006). Breaking and creating habits on the working floor: A field-experiment on the power of implementation intentions. *J. Exp. Soc. Psychol.* 42, 776–783. doi: 10.1016/j.jesp.2005.11.006
- IEA (2017). *Water-Energy Nexus*. Paris: IEA. Available at: <https://www.iea.org/reports/water-energy-nexus> (accessed April 30, 2024).
- Lally, P., Van Jaarsveld, C. H., Potts, H. W., and Wardle, J. (2010). How are habits formed: Modelling habit formation in the real world. *Eur. J. Soc. Psychol.* 40, 998–1009. doi: 10.1002/ejsp.674
- Locke, E. A., and Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: a 35-year odyssey. *Am. Psychol.* 57, 705–717. doi: 10.1037/0003-066X.57.9.705
- Lokhorst, A. M., Werner, C., Staats, H., van Dijk, E., and Gale, J. L. (2013). Commitment and behavior change: a meta-analysis and critical review of commitment-making strategies in environmental research. *Environ. Behav.* 45, 3–34. doi: 10.1177/0013916511411477

Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1465696/full#supplementary-material>

- Maréchal, K. (2010). Not irrational but habitual: the importance of “behavioural lock-in” in energy consumption. *Ecol. Econ.* 69, 1104–1114. doi: 10.1016/j.ecolecon.2009.12.004
- Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., and Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. *Ann. Card. Anaesth.* 22, 67–72. doi: 10.4103/aca.ACA_157_18
- Mometrix (2023). *Reading Comprehension Practice Test 2*. Available at: <https://www.testprepreview.com/modules/reading2.htm> (accessed November 16, 2022).
- Orne, M. T. (1962). On the social psychology of the psychological experiment: with particular reference to demand characteristics and their implications. *Am. Psychol.* 17, 776–783. doi: 10.1037/h0043424
- Osbaldiston, R., and Schott, J. P. (2012). Environmental sustainability and behavioral science: meta-analysis of proenvironmental behavior experiments. *Environ. Behav.* 44, 257–299. doi: 10.1177/0013916511402673
- Prochaska, J. O., and DiClemente, C. C. (1983). Stages and processes of self-change of smoking: toward an integrative model of change. *J. Consult. Clin. Psych.* 51, 390–395. doi: 10.1037/0022-006X.51.3.390
- Ralph, K. M., and Brown, A. E. (2019). The role of habit and residential location in travel behavior change programs, a field experiment. *Transportation* 46, 719–734. doi: 10.1007/s11116-017-9842-7
- Rebar, A. L., Gardner, B., Rhodes, R. E., and Verplanken, B. (2018). “The measurement of habit” in *The Psychology of Habit: Theory, Mechanisms, Change, and Contexts*, ed. B. Verplanken (Cham, Switzerland: Springer), 31–49.
- Rise, J., Thompson, M., and Verplanken, B. (2003). Measuring implementation intentions in the context of the theory of planned behavior. *Scand. J. Psychol.* 44, 87–95. doi: 10.1111/1467-9450.00325
- Schäfer, M., Jaeger-Erben, M., and Bamberg, S. (2012). Life events as windows of opportunity for changing towards sustainable consumption patterns? Results from an intervention study. *J. Consum. Policy* 35, 65–84. doi: 10.1007/s10603-011-9181-6
- Swaffield, J., Whitmarsh, L., and Poortinga, W. (2023). Interrupting the flow of water: Behavioural interventions and moments of change. *Institute of Water J.* 8, 4–5. Available at: https://orca.cardiff.ac.uk/id/eprint/166174/1/Swaffield_Main%20Text.docx.pdf
- Thøgersen, J. (2012). “The importance of timing for breaking commuters’ car driving habits” in *The Habits of Consumption*, eds. A. Warde and D. Southerton (Helsinki: Helsinki Collegium for Advances Studies), 130–140. Available at: <https://helda.helsinki.fi/collections/9a73282a-92eb-48a6-aa5a-33ed9a239e49> (accessed April 30, 2024).
- Thomas, G. O., Poortinga, W., and Sautkina, E. (2016). Habit discontinuity, self-activation, and the diminishing influence of context change: evidence from the UK understanding society survey. *PLoS ONE* 11:e0153490. doi: 10.1371/journal.pone.0153490
- Tijds, M. S., Karremans, J. C., Veling, H., de Lange, M. A., van Meegeren, P., and Lion, R. (2017). Saving water to save the environment: contrasting the effectiveness of environmental and monetary appeals in a residential water saving intervention. *Soc. Influence* 12, 69–79. doi: 10.1080/15534510.2017.1333967
- Universities UK (2024). *UUK/GuildHE Accommodation Code of Practice List of Registered Properties by Member: October 2023*. Available at: <https://www.universitiesuk.ac.uk/topics/students/student-support/accommodation-code-practice> (accessed June 18, 2024).
- Verplanken, B., and Aarts, H. (1999). Habit, attitude, and planned behaviour: Is habit an empty construct or an interesting case of goal-directed automaticity? *Eur. Rev. Soc. Psychol.* 10, 101–134. doi: 10.1080/14792779943000035
- Verplanken, B., and Orbell, S. (2003). Reflections on past behavior: a self-report index of habit strength. *J. Appl. Soc. Psychol.* 33, 1313–1330. doi: 10.1111/j.1559-1816.2003.tb01951.x
- Verplanken, B., and Roy, D. (2016). Empowering interventions to promote sustainable lifestyles: testing the habit discontinuity hypothesis in a field experiment. *J. Environ. Psychol.* 45, 127–134. doi: 10.1016/j.jenvp.2015.11.008
- Verplanken, B., Roy, D., and Whitmarsh, L. (2018). “Cracks in the wall: Habit discontinuities as vehicles for behaviour change” in *The Psychology of Habit: Theory, Mechanisms, Change, and Contexts*, ed. B. Verplanken (Cham, Switzerland: Springer), 189–205.
- Verplanken, B., and Whitmarsh, L. (2021). Habit and climate change. *Curr. Opin. Beh. Sci.* 42, 42–46. doi: 10.1016/j.cobeha.2021.02.020
- Veseley, S., and Klöckner, C. (2020). Social desirability in environmental psychology research: three meta-analyses. *Front. Psychol.* 11, 1395. doi: 10.3389/fpsyg.2020.01395
- Walton, A., and Hume, M. (2011). Creating positive habits in water conservation: the case of the Queensland Water Commission and the Target 140 campaign. *Int. J. Nonprofit Voluntary Sector Market.* 16, 215–224. doi: 10.1002/nvsm.421
- Waterwise (2024). *Save Water*. Available at: <https://www.waterwise.org.uk/save-water/> (accessed July 11, 2024).
- Whitmarsh, L., Poortinga, W., and Capstick, S. (2021). Behaviour change to address climate change. *Curr. Opin. Psychol.* 42, 76–81. doi: 10.1016/j.copsyc.2021.04.002
- Wobbrock, J. O., Findlater, L., Gergle, D., and Higgins, J. J. (2011). “The aligned rank transform for nonparametric factorial analyses using only anova procedures,” in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 143–146.
- Wolfstenholme, E., Poortinga, W., and Whitmarsh, L. (2020). Two birds, one stone: the effectiveness of health and environmental messages to reduce meat consumption and encourage pro-environmental behavioral spillover. *Front. Psychol.* 11, 577111. doi: 10.3389/fpsyg.2020.577111



OPEN ACCESS

EDITED BY
Giuseppe Carrus,
Roma Tre University, Italy

REVIEWED BY
Elisabetta Ricciardi,
University of Bari Aldo Moro, Italy
Oriana Mosca,
University of Cagliari, Italy

*CORRESPONDENCE
Mehmet Efe Biresselioglu
✉ efe.biresselioglu@ieu.edu.tr

RECEIVED 27 February 2024
ACCEPTED 14 November 2024
PUBLISHED 11 December 2024

CITATION
Biresselioglu ME and Demir MH (2024) From
concept to impact: strategic guidelines for
environmental behavior change interventions.
Front. Psychol. 15:1392461.
doi: 10.3389/fpsyg.2024.1392461

COPYRIGHT
© 2024 Biresselioglu and Demir. This is an
open-access article distributed under the
terms of the [Creative Commons Attribution
License \(CC BY\)](#). The use, distribution or
reproduction in other forums is permitted,
provided the original author(s) and the
copyright owner(s) are credited and that the
original publication in this journal is cited, in
accordance with accepted academic
practice. No use, distribution or reproduction
is permitted which does not comply with
these terms.

From concept to impact: strategic guidelines for environmental behavior change interventions

Mehmet Efe Biresselioglu* and Muhittin Hakan Demir

Sustainable Energy and Climate Policies Research Centre (SENLAB), Izmir University of Economics, Izmir, Türkiye

Interventions aiming at behavioral change are common tools for assessing and stimulating environmentally friendly lifestyles. To obtain representative and scalable results from the interventions, the experimental design of the interventions is crucial. Likewise, an operational plan is significant concerning the coherence and consistency of the interventions and the comparability of the results from different interventions. Such a guideline contributes to the design, execution, and supervision of the interventions, provides standardisation and enhances collaboration with the intervention partners. Intervention guidelines also pertain to the strategic planning of data requirements and collection procedures. Based on the work conducted within the context of the EU-funded ENCHANT project, the guidelines presented in this manuscript are structured based on the key phases of planning and design, implementation, and analysis and reporting. Another key area that needs to be considered and included in the guidelines is the planning necessities for the administrative structure for the interventions. This includes allocating staff roles and responsibilities and potential challenges and obstacles that may arise during implementation. Ethical concerns are also addressed.

KEYWORDS

intervention, guideline, behavioral change, monitoring, ethics

1 Introduction

The climate crisis becomes more visible through increasing greenhouse gas emissions, global warming, rising sea levels, and extreme weather events (IPCC, 2021). Climate change and environmental issues are closely related with human behavior such as the extensive use of fossil fuels (Gatersleben et al., 2023). Hence, individuals and households are significant in terms of combating the effects of climate change (Rau et al., 2022). However, it is not a straightforward task to motivate individuals towards pro-environmental behaviors (van Valkengoed et al., 2022). To this end, in recent years, the European Commission has significantly emphasised reducing carbon emissions from energy production and increasing energy efficiency in European lifestyles and economies. The European Climate Pact [European Commission (EC), 2021] sets ambitious goals, making energy transition a central focus, emphasising household-level energy efficiency improvements. Research and projects concerning behavioral change aim to increase the practices of energy efficiency among individuals and the public. Such endeavours utilise interventions to reach a high number of citizens. These interventions are critical in addressing negative behaviors and transforming them towards pro-environmental behaviors (Michie et al., 2011; Castán Broto and Bulkeley,

2013). These interventions can also be utilized as part of the proactive actions for climate change mitigation (Castán Broto and Bulkeley, 2013). Research on behavioral interventions is mainly focused towards identifying which interventions ‘work’ for which settings in order to encourage pro-environmental behavior and mitigate climate change. That is, such research seeks to determine the most effective intervention types (van Valkengoed et al., 2022). However, the effectiveness of interventions vary from one study to the other (Abrahamse and Steg, 2013).

A criticism of the behavioral interventions is that they are usually not based on well-defined methods (Rau et al., 2022). This calls for a more rigorous research design, along with well-defined guidelines to enhance causal inference. The existence of and adherence to such guidelines contribute to the reliability of the findings, replicability of the interventions, for instance, via reporting. Guidelines also foster a better understanding of the underlying processes, moderators, and mediators of the intervention (Gatersleben et al., 2023). Ehret et al. (2021) emphasize that the variety of implementation and evaluation methodologies for interventions make it difficult to perform a meta-analysis. Therefore, using more standard guidelines for interventions also contribute to the consistency in approaches, cross-comparability, and a larger base of effective interventions (Staddon et al., 2016). Planning interventions also enhances the proper allocation of resources and reducing the costs of the interventions (Gatersleben et al., 2023).

The experimental design of the interventions is crucial to obtaining representative and scalable results from the interventions. Likewise, an operational plan is significant concerning the coherence and consistency of the interventions and the comparability of the results from different interventions. Such a guideline reflects the design, execution, and supervision of the interventions, provides standardisation and enhances collaboration with the intervention partners. Intervention guidelines also pertain to the strategic planning of data requirements and collection procedures. The spectrum of intervention types, geographical, cultural, and organisational coverage of interventions makes it more crucial to identify a set of guidelines for implementation and monitoring of the interventions.

One key area that needs to be considered and included in the guidelines is the planning necessities for the administrative structure for the interventions. This includes allocating staff roles and responsibilities and potential challenges and obstacles that may arise during implementation. Ethical concerns are also addressed.

One crucial and complementary facet of the interventions is the meetings that enhance the collaboration between the various stakeholders of the interventions. Even though the theoretical design of the interventions may be designed with the utmost care, considering the relevant parameters, successful implementation of the interventions requires continuous monitoring and fine-tuning for configuring in terms of technical compatibility, alignment with geographical considerations, the availability and accessibility of communication channels, the potential to achieve the desired impact, and the needs of the target population. Hence, meetings for continuous monitoring and fine-tuning help to ensure smoother implementation and a more significant impact. With this perspective, interventions also serve to pinpoint the precise conditions under which intervention designs can be implemented successfully and effectively.

Another dimension concerning the stakeholders involved in implementing the interventions including energy providers and producers, government energy agencies and local administrations, and NGOs is the need to exploit their communication channels to connect with the target populations and implement interventions to foster alterations in energy-related behaviors. The multitude of these communication channels, advertising campaigns, web portals, SMS notifications, and smartphone apps emphasise the need to establish a unifying framework for implementing interventions that will be valid across all communication channels for enhancing the standardisation of the implementation and analysis.

The guidelines depicted in this manuscript are developed for the EU-funded ENCHANT Project (n.d.). ENCHANT has three principal objectives including: shifting the energy behavior of European households toward sustainability under real-world conditions, evaluating and systematising existing theoretical models, empirical data, and best practices related to psychological interventions that drive more sustainable energy choices, and exploring psychological, social, and contextual drivers of energy choices and sustainable energy lifestyles in European society. The project has utilised practical interventions for assessing how these factors can be effectively addressed in an implementable, replicable, and scalable setting at European, national, and local levels. The overall objective of the ENCHANT project is to support the energy transition by testing the impact of interventions affecting energy consumption behavior on a large scale across Europe. For this purpose, the project collaborated with user-partners which are energy companies, municipalities, and environmental NGOs in seven European countries. ENCHANT has tested established science-based behavioral intervention techniques in real-life settings in six countries (Norway, Italy, Romania, Türkiye, Austria and Germany) (ENCHANT Project, n.d.). The main results of the ENCHANT project include a policy matrix that demonstrates the strengths and potential weaknesses of interventions and offers behavioral strategies for practical implementation (ENCHANT Project, n.d.). The ENCHANT project has also developed the EnergyWizard tool that utilises the machine-learning with the projects’ findings for identifying the best intervention or a best combination of interventions along with the suitable communication channel for a group of people (ENCHANT Project, n.d.).

The ENCHANT project has started with developing intervention packages through an extensive review of theoretical models, empirical data, and best practices of psychological interventions designed to influence human behavior in the context of sustainable energy choices. Such analysis provided pointers for the design of interventions with the potential for scaling up. The next step was to establish procedures and protocols for the standardization of the interventions and the analysis.

The intervention development and implementation details are specified in the guidelines, application principles, and an operational implementation plan. As discussed above, such guidelines and operational plans are needed to ensure a successful implementation, provide standardisation, identify points of deviation from the plan, and formulate solutions to recover the intervention progress according to the plan.

The stakeholders involved in the interventions are significant in affecting the implementation and results of the interventions. The skills, competencies, capacities, capabilities, and resources of the

intervention partners are significant drivers of the performance of the interventions. The ENCHANT project has collaborated with three key stakeholders to design and implement the interventions, focusing on specific groups and target populations. The first type of main stakeholders are energy providers and producers in the electricity and gas sectors. These stakeholders mainly participate in interventions concerning feedback on consumption, the provision of information, and the influence of social norms on the energy consumption patterns of individuals and households. The second type of stakeholders is the government energy agencies and local administrations such as municipalities. These stakeholders contribute mainly to interventions based on information dissemination, encouraging commitment, or organising energy-saving competitions to promote more sustainable energy behaviors among the broader public. The final type of stakeholders is the Non-Governmental Organizations (NGOs). NGOs operating in the energy and sustainability sector enhance the engagement of specific stakeholders and organised groups within civil society and the general public and contribute to the design and evaluation of interventions that rely on strategies like commitment-building, the dissemination of information, or influencing social norms, advocating for a sustainable energy transition and the adoption of sustainable lifestyles.

During the design and planning of the interventions, the data to be collected plays an essential role for measuring the impacts across various categories, such as policy support, public awareness, outreach, household interventions, primary energy savings, greenhouse gas emissions reduction, investments, and additional impacts. For this purpose, Key Performance Indicators (KPIs) are designed to specify how the performance of the interventions will be measured, and which data needs to be collected for these measurements.

The knowledge and experience gained from the interventions are also utilised to identify policy instruments that can be implemented and enablers and barriers in implementation and explore ways to enhance the potential for enablers to overcome barriers in real-life situations.

The guidelines for the interventions of the ENCHANT project were designed utilizing various systematic frameworks (Sundnes, 2014a; Sundnes, 2014b; Sundnes, 2014c; Hales et al., 2016). Other frameworks for interventions have also been developed. However, these frameworks mainly pertain to the research design (e.g., MINDSPACE), linking interventions to target behaviors (e.g., the behavioral change wheel), or limited to the public policy domain (e.g., BASIC) (Dolan et al., 2012; Michie et al., 2011; OECD, 2019).

The main types of interventions implemented by the ENCHANT project are feedback on own consumption, social norms, information provision including simplification, monetary incentives, commitment, competition, and collective and individual framing.

Within the context of energy-related behavior, feedback on own consumption involves informing individuals about their energy usage patterns and encouraging behavior change based on this information. Feedback interventions are effective via reflection on the outcomes of one's behavior but are dependent on the individual's awareness (Hayes and Cone, 1981; Bekker et al., 2010; Petersen et al., 2007; Xu et al., 2021; Shen et al., 2020a; Legault et al., 2020; Shen et al., 2020b; Canale et al., 2023).

Social norms, on the other hand, involve providing individuals with information about the energy consumption behavior of others and the socially acceptable standards of energy-related behavior,

eliciting their approval or disapproval of specific behaviors. This type of interventions has the advantage of utilizing norms for behavior change. However, the efficiency is dependent on the individual's perception of norms (Schultz et al., 2007; Graziano and Gillingham, 2015; and Barth et al., 2016; de Groot et al., 2021; Hewitt et al., 2023; Helferich et al., 2023; Belaïd and Flambarb, 2023).

Information-provision based interventions offer individuals targeted data, providing information on, for instance, the environmental impact of one's activities to encourage people to embrace energy conservation behaviors. Information provision is one of the most important prerequisites of behavior change. On the other hand, the effectiveness of this type of intervention is sensitive to the communication channel used (Komatsu and Nishio, 2015; Aydin et al., 2018; Asmare et al., 2021; Mundaca et al., 2023; Liu et al., 2023).

Monetary incentives refer to identifying how financial savings can motivate energy-related behaviors (Kwan, 2012; Alberini and Bigano, 2015; Dharshing, 2017; Ek and Söderholm, 2008; Neumann and Mehlkop, 2020; Wang et al., 2021; Sloot and Scheibehenne, 2022). A common type of interventions uses commitment strategies by asking participants to commit to specific energy-saving behaviors for motivating sustainable and pro-environmental behavior (Schwartz et al., 2015; Steinhörst and Klöckner, 2017; Xu et al., 2018; Rajapaksa et al., 2019; Ji et al., 2023; Kramer and Petzoldt, 2023).

Another type of intervention utilizes the idea of competition, where the participants with the best energy-saving performance are awarded. Such interventions have the advantage of engaging people in energy conservation and raise awareness about the connection between behavior change and energy use. However, it may be difficult to motivate individuals to stay in the competition (Konis et al., 2016; Bergquist et al., 2017; Nockur and Pfattheicher, 2020; Xie et al., 2021; Fijnheer et al., 2021).

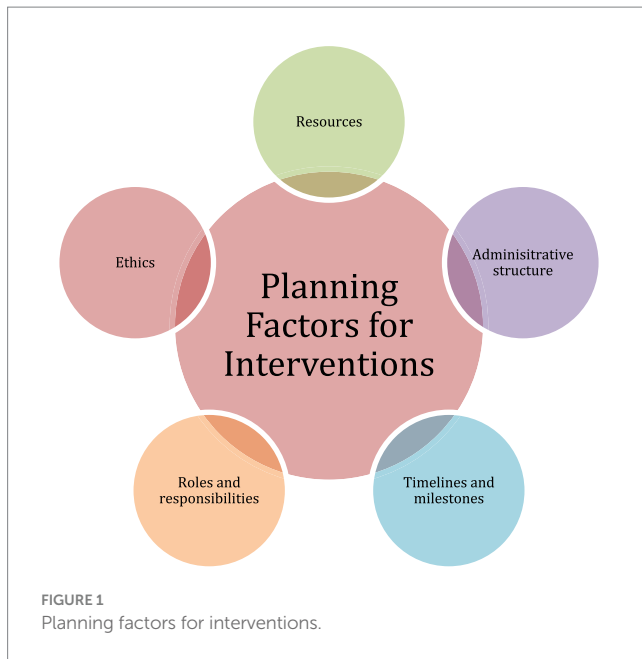
The last type of intervention considered is collective or individual framing to influences people's behavior and choices regarding sustainable initiatives. Framing interventions may utilize social comparison, goal setting, or commitment and are often evaluated in conjunction with the impact of social norms and norm-based strategies on long-term behavior. Hence, this type of interventions also depends on the individuals' perception on and adherence to norms (Xu et al., 2015; Ghesla et al., 2020; Kacperski et al., 2023; Mäkiävierikko et al., 2023; Syropoulos et al., 2023).

2 Materials and equipment

The intervention guidelines rely on materials and equipment, or planning assets involving resources, timelines and milestones, administrative structure, roles and responsibilities, timelines and milestones, and ethics. Figure 1 demonstrates these factors.

2.1 Resources

Establishing the conformity of the intervention goals and objectives with the available and accessible resources in terms of personnel, equipment, and supplies is critical for successful implementation. Such endeavour involves a clear and SMART (specific, measurable, achievable, relevant, and time-bound) identification of the goals and



objectives of each intervention package and matching these to the available resources, including personnel, equipment, materials, communication channels, and additional workforce. At this point, it is crucial to collaborate with partners and stakeholders to understand their unique needs, experiences, and constraints.

Critical considerations for resource planning are identifying priorities, collaborative planning, need assessment reporting, budget preparation, reporting, monitoring resources, considering resource efficiency, and establishing continuous communication. The allocation of resources according to the priority and importance of the goals and objectives amounts to considering the expected impact and the feasibility of achieving the goals with the available resources and allocating resources accordingly. Need assessment reporting refers to partners and stakeholders reporting the resources they need and how they plan to use them to implement the interventions. This includes details on the personnel or teams involved, the materials or equipment required, and any additional workforce that might be necessary. Collaborative planning is crucial to incorporate stakeholders' past and current experiences and ensure that all stakeholders have a clear understanding of roles and responsibilities. Budgeting safeguards the resource-wise feasibility of the interventions by outlining the financial requirements associated with resource allocation. This budget considers personnel costs, material expenses, equipment procurement, and other related costs. Monitoring resources refers to the resources needed for continuous monitoring and adjusting if resource constraints or unexpected challenges arise. Considering resource efficiency amounts to tracking and evaluating the cost-effectiveness of the interventions. Regular communication aims to maintain open lines of communication with user partners throughout the intervention to address any resource-related issues and provide support as needed.

2.2 Administrative structure

Creating a clear administrative structure for each intervention is essential for ensuring that roles and responsibilities are well-defined,

leading to efficient coordination and execution of interventions. Establishing a well-defined administrative structure enhances project management, minimises confusion, and facilitates more effective collaboration between users and scientific partners within the ENCHANT project. It is a critical component of successful intervention implementation. The key steps in establishing an administrative structure include defining job descriptions, identifying the staff responsible, the number of personnel and lines of responsibility, and succession planning.

Defining job descriptions starts with clearly defining the job descriptions for each role within the administrative structure, including the key responsibilities and tasks associated with each role, aligning with the objectives and requirements of the intervention plan. After that, the specific staff members responsible for each role within the administrative structure need to be determined. In doing so, the skills and expertise of the staff need to be matched with the tasks. The number of personnel involved in each role needs to be specified, considering the workload and complexity of tasks when determining the required staffing levels and project requirements. A complementary planning aspect is the definition of the lines of responsibility to establish reporting and communication channels, reporting schemes, and information flow. In anticipation of staff turnover and changes in responsibilities, a succession plan needs to be developed to ensure a smooth transition when staff changes occur. This may involve cross-training or identifying potential replacements in advance.

For the timely achievement of milestones, the administrative structure needs to be linked to the achievement of project milestones. Each role should have a clear connection to specific milestones to ensure that responsibilities are met within the project timeline.

2.3 Roles and responsibilities

The operational intervention plan should include the project partners' and stakeholders' roles and responsibilities. The partners are expected to define the specific roles and responsibilities as position descriptions for the personnel stating the required level of expertise in the related subject. Accordingly, the partners should address the competencies required and the qualifications needed. The roles and responsibilities must be clearly defined for an efficient management framework and governance structure.

The critical roles for each partner include a main responsibility (operational administrator), recruitment staff, staff responsible for the implementation and monitoring, data collection personnel, and data protection officer.

The operational administrator is responsible for examining the intervention progress periodically, executing corrective action where there is a failure to achieve tasks on time, ensuring that resources will be available when needed, and supervising, supporting and encouraging the staff to ensure that tasks are undertaken and reporting problems to other relevant partners.

The intervention recruitment staff establishes experiment and control groups by identifying potential research participants, delivering the informed consent procedures necessary for participation, and preparing templates of the Informed Consent Forms and Information Sheets covering voluntary participation and data protection issues in intelligible terms.

The staff responsible for the implementation and monitoring will organize the initiation, application and completion of the intervention by coordinating with other staff members regarding the activities in the intervention strategy and the timeline, ensuring the proper use of resources (human and/or material resources) for the achievement of the intervention's goals, planning and organizing the method and timeline for how and when the resources will be used (e.g., in the case that posters or billboards are used for informative purposes, when, how and where these will be used), mitigating the effects of delays, interruptions and obstacles that are likely to pose barriers for efficient and routine-functioning of the intervention plans, managing the process and people/staff, ensuring the milestones are achieved, ensuring that all staff have the necessary information and resources to complete the tasks and discharge their responsibilities, communicating any changes to the relevant partners and stakeholders, ensuring that the ethical considerations are followed, and reviewing each member of personnel's workloads and responsibilities.

The roles and responsibilities of the data collection personnel and data protection officer are signing and collation all necessary Informed Consent Forms before the collection of any data, securely storing the forms afterwards, ensuring required anonymisation is performed during data collection and processing, confirming that all data collection and processing will be carried out according to EU and national legislation, reporting the collected data for archiving, and providing detailed information for archiving on the procedures to be implemented for data collection, storage, protection, retention, and destruction, and confirmation that these procedures comply with national and other relevant legislations such as the EU legislation.

2.4 Timelines and milestones

Establishing a realistic and agreed-upon timeline with well-defined milestones is crucial for successfully implementing interventions. The key steps for developing and managing the timeline and milestones involve setting realistic timelines, collaborative agreements, specifying milestones, documenting milestones, assigning responsibilities, setting target dates, periodic tracking and reporting, flexible adaptation, communication, and recording milestone achievements.

Setting realistic timelines and estimating the time required to complete each project phase is significant. Factors such as recruitment, data collection, and implementation complexities need to be considered while avoiding setting overly ambitious or unattainable deadlines, as this can lead to frustration and potential setbacks. A collaborative agreement involving all partners and stakeholders in setting timelines and milestones is important as this provides a consensus on the proposed timeline, ensuring that all stakeholders understand the project's timing. Specifying the measurable milestones, significant events or achievements that mark key progress points throughout the intervention process and documenting each milestone with clear descriptions of what should be achieved at each stage helps ensure that all stakeholders understand what is expected at each milestone. Once the timelines and milestones are agreed upon, assigning responsibilities for monitoring and achieving each milestone via identifying the key individuals or teams responsible for completing specific milestones ensures accountability and a focused effort to meet deadlines. Based

on the timelines, target dates need to be set for each milestone. These dates should be based on a realistic assessment of each phase's length and ensuring that target dates are aligned with the overall project timeline. Establishing the guidelines and a schedule for periodic tracking and reporting progress on milestones involves regular check-ins and updates, essential to monitor progress and identify any delays or issues early on. Project timelines may need to be adjusted through flexible adaptation as the project unfolds. This requires adapting and modifying timelines and milestones based on changing circumstances, challenges, or opportunities. As with all stages of the planning framework, effective communication is key to keeping all stakeholders informed about progress, challenges, and adjustments. Open and transparent communication ensures everyone is on the same page and can work collaboratively to address issues. Finally, recording milestone achievements by maintaining clear records of when each milestone is achieved helps track the project's progress and can be valuable for evaluating the success of the intervention.

A standardised schema for timelines and milestones is crucial to any project, especially for more complex and collaborative projects. It facilitates coordination and progress tracking and allows for efficient communication among partners and stakeholders. Assessing and evaluating deviations from the timelines is essential for proactive problem-solving and managing unforeseen challenges. This practice helps identify critical issues early and find appropriate solutions, ultimately ensuring the successful implementation of interventions. The flexibility to adapt timelines and milestones in response to changing conditions or resource availability is a practical approach that can contribute to the overall effectiveness of the project. This standardised schema is a valuable tool for keeping the project on track and meeting its objectives.

2.5 Ethics

Ethical factors and compliance with national and international (such as European regulations) are crucial throughout the interventions. Data protection and informed consent need to be addressed, particularly in personal data collection. The interventions need to follow a comprehensive ethical framework to protect the rights and privacy of research participants while conducting interventions and data collection. This approach ensures that the research conducted is scientifically sound and respectful of ethical principles and legal requirements. The ethical framework for interventions includes concerns regarding recruitment, informed consent procedures, data collection and processing activities, data storage and curation, and anonymisation.

Concerning recruitment, voluntary participation and opt-out need to be secured. The interventions should target adult participants who can provide informed consent. Participants need to be informed about the study's purpose, data collection procedures, and the potential usage of data, such as energy consumption data. Participants need to have the right to withdraw from the study without facing any penalties or providing a reason. A contact channel (phone and email) needs to be provided for participants to inquire about their stored data. All information needs to be presented in written form during the recruitment process, and informed consent forms need to be signed before any data collection activity.

Written informed consent needs to be sought from participants wherever possible; explicit online consent can be used for online surveys. Informed consent needs to comply with forms provided by relevant authorities and organisations. Templates for consent forms and information sheets must be prepared in national languages when necessary and archived.

Ethical data collection principles must be addressed to ensure quality, accuracy, efficiency, effectiveness, feasibility, and security. Procedures need to be developed to meet general scientific quality criteria, and data must be correct, complete, and reliably entered. Confidentiality and data protection need to be ensured in line with legal requirements.

Personal data needs to be stored in safe storage spaces, and periodic backup routines need to be implemented to prevent data loss.

Data Anonymization is a crucial practice to protect the privacy of stakeholders and users. Personally identifiable data need to be anonymised and aggregated. The mapping between anonymised and actual IDs must be safeguarded and accessible only to those directly working with the data.

3 Methods

The guidelines and application principles for the interventions cover the preliminary work and actual implementation, along with a phased timeline for monitoring and follow-up. Among the objectives of these guidelines are to ensure appropriate timeline management, resource allocation, and operational planning to maximise the likelihood of achieving the desired impact, as well as collecting the data for analysing the intervention results and enhancing the replicability and reproducibility of interventions.

As part of the process, the guidelines and operational plan for the interventions have been developed using a framework that addresses key issues of autonomy, information exchange, governance, and clearly defined responsibilities. The Guidelines and Operational Intervention Plan begins by selecting intervention types for each user-partner. It then proceeds through a multi-staged planning framework,

with defined milestones for each stage. This framework provides a structured approach to ensure the interventions are effectively designed and implemented.

3.1 The process for designing the guidelines and the planning framework

The guidelines are prepared considering a comprehensive framework, including data analysis, impact assessment, tool creation, and effective dissemination of results to various stakeholders. The work for preparing the guidelines is supported by different pre-intervention work packages involving methodology design, ethics, data management, intervention design, protocol design, and pilot interventions, and post-intervention work packages involving tools for replicability, suitability for upscaling, and comparability, impact assessment and evaluation.

The planning framework for the efficient and effective implementation of interventions involves three main phases, each corresponding to one stage in the timeline of the systematic planning process. These phases are, Planning and Design, Intervention Implementation, and Analysis and Reporting.

Phase 1—Planning and Design refers to defining the intervention, focusing on the current situation, needs, and concerns. Understanding the specific characteristics, needs, and concerns of the target population and documenting the current situation is crucial. This information influences the intervention strategy. The intervention design then takes into consideration the analysis of the current situation and designs the interventions to maximise changes in energy-related behaviors while suiting the current situation of the relevant society. Significant considerations at this stage include implementability, replicability, and upscalability. Following the intervention design, the next step is the pre-implementation preparation. This step focuses on the practical aspects that should be considered before the intervention kick-off, such as setting up the administrative structure, assigning roles and responsibilities, educating and training personnel, and identifying necessary communication channels and equipment. [Figure 2](#) provides an overview of the first phase.

Step 1 Defining the Intervention

Step 2 Intervention Design

Step 3 Pre-implementation preparation

- Setting up the administrative structure
- Identifying communication channels
- Education and training

FIGURE 2
Phase I: planning and design.

Following the planning and design phase, the second phase is the Intervention Implementation Phase. Phase II is the most extensive phase and involves a wide spectrum of stages to ensure the success of the interventions. To begin with, the Intervention Implementation Phase involves establishing effective communication with the project coordinator and implementation partners, which is particularly essential for coordination and progress monitoring as well as for smooth progress and identifying solutions to potential challenges. A critical component of Phase II is setting a timeline and constructing a standardised reporting structure. This stage involves specifying timelines and milestones, which are crucial for tracking progress and maintaining the project schedule since standardised reporting enhances the measurement of success.

The following stage is the recruitment stage, where participants are selected and recruited, informed consent is secured, and the purpose of the study is explained. The recruitment stage is complemented by randomisation and pre-intervention data collection stages. In the randomisation stage, participants are randomly assigned to experimental and control groups. This is vital to maintain methodological rigour and prevent self-selection bias. In the pre-intervention data collection stage, data is collected from participants before the intervention begins to establish baseline information.

The next stages of the Intervention Implementation Phase include intervention kick-off, intervention implementation and monitoring, post-intervention data collection, and intervention closure. The intervention kick-off is conducted through the designated communication channels after ensuring that the preceding planning steps are completed. Intervention implementation and monitoring keep track of the intervention progress and milestones. This stage also involves identifying deviations from the plan, developing measures to recover the intervention progress, and adapting to unexpected events

during intervention implementation. Post-intervention data collection is as important as the intervention implementation since the performance of the intervention cannot be assessed without collecting the post-intervention data and comparing it with the pre-intervention data to identify the behavioral changes resulting from the intervention. The final stage of the Intervention Implementation Phase is intervention closure, which involves reaching milestones, completing relevant tasks, and communicating with relevant stakeholders about the completion of the intervention. Figure 3 provides an overview of Phase II.

The third phase of planning is the Analysis and Reporting phase. This phase involves the analysis of the data collected during the pre-intervention, intervention, and post-intervention stages, including primary and secondary data. An essential aspect to handle at this step is the anonymisation of data to comply with privacy and ethical considerations. Following the analysis of the intervention data, the intervention needs to be reported transparently to demonstrate the quality of the study and allow for verification by others. The final stage of the Analysis and Reporting Phase is the commonly overlooked data management and storage stage. The guidelines aim to ensure that interventions are designed, implemented, and reported transparently and systematically, allowing for verification and further research. Data management and storage principles include recording and securely holding data with metadata, backing up electronic data, and ensuring digital continuity and future accessibility. These principles are crucial to safeguard data security and accessibility while promoting future research opportunities. These stages are demonstrated in Figure 4.

Table 1 provides a checklist that can be adapted for a particular intervention and utilised to keep track of the operational steps of interventions.

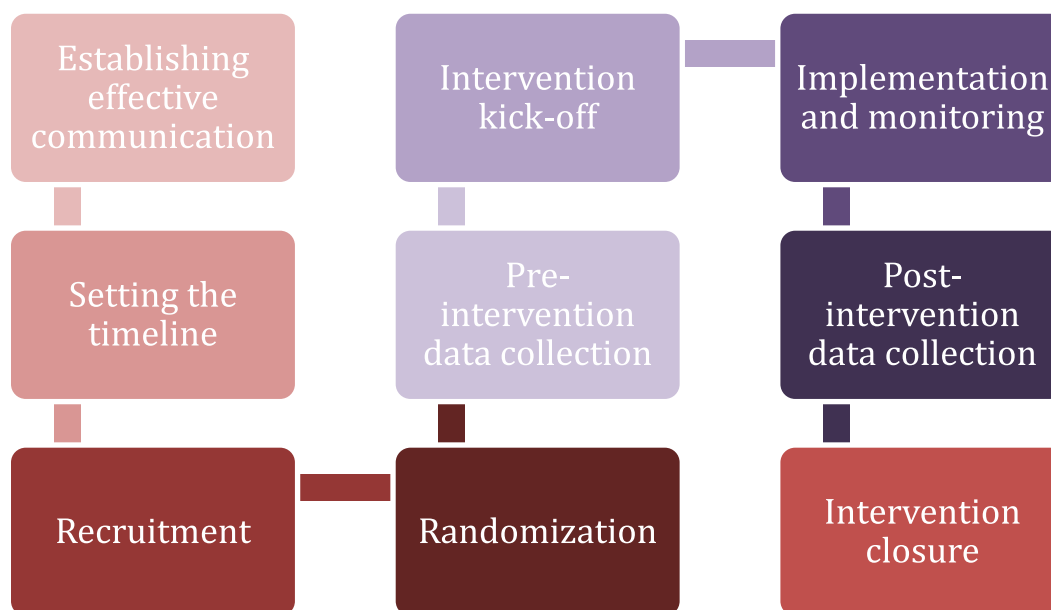


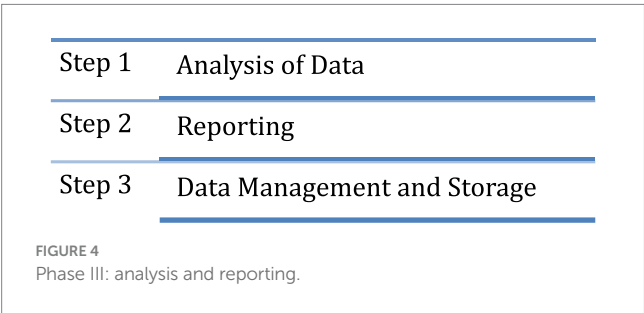
FIGURE 3
Phase II: intervention implementation.

4 Results

For achieving the desired results from the interventions, other key factors that need to be considered include operational monitoring mechanisms, proper reporting of the intervention process, and *a priori* consideration of the challenges and barriers.

4.1 Operational monitoring mechanisms

A methodological approach is needed for operational monitoring mechanisms for interventions to ensure efficient oversight of the intervention implementation process. Based on the process control techniques (Pourmirza et al., 2017; Jakhar, 2017; Cangussu et al., 2003), operational monitoring mechanisms aim to track, assess, and measure the actual performance of interventions in comparison to the expected mode of operation. The key steps and processes involved are defining the planned/expected mode of operation, tracking the implementation, assessing/measuring the actual performance, comparing the actual performance with the expected mode of operation and identifying the differences/deviations from the expected mode of operation, and determining reasons for differences/deviations



from the expected mode of operation and taking actions for restoring the expected mode of operation.

Defining the planned/expected mode of operation refers to analysing the intervention designs and planning guidelines for establishing intervention timelines, identifying data requirements for key performance indicators (KPIs), and considering compliance with ethical and data protection requirements.

Tracking the Implementation process through the key stages, including recruitment, randomisation, pre-intervention data collection, intervention kick-off, execution of the intervention, post-intervention data collection, and closure, is central to intervention monitoring. This can be efficiently done using an intervention monitoring checklist and an intervention timeline Gantt Chart to track and monitor the timely execution of the intervention stages. A sample intervention monitoring checklist that can be adapted for particular interventions is demonstrated in Table 1 in the Appendix.

For assessing or measuring the actual performance of the intervention, KPIs on the progress and outcomes at each stage are utilised, monitoring actual numbers, timelines, and data collection procedures and validating data collection processes. A comparison is made between actual performance and the planned mode of operation. For this purpose, both qualitative and quantitative assessments are included. In case of differences or deviations from the planned mode of action, stakeholders are consulted to assess the impact of deviations and actions are planned and implemented to restore the expected mode of operation and mitigate impacts.

The monitoring framework is implemented periodically to ensure interventions progress as planned, where the monitoring frequency is determined based on the specific intervention's needs. The monitoring framework allows for periodic and additional monitoring, depending on the feedback and issues raised during the implementation. This approach ensures that deviations and challenges are promptly addressed, data collection processes

TABLE 1 Intervention guideline checklist.

Step	Action	Date planned for completion	Actual completion date	Deviation(s)	Corrective measures
1	Define the intervention				
2	Design the intervention				
3	Setup administrative structure				
4	Assign roles and responsibilities				
5	Education and training				
6	Identify communication channels				
7	Set the timeline				
8	Recruitment				
9	Randomization				
10	Pre-intervention data collection				
11	Intervention closure				
12	Analysis of data				
13	Reporting				

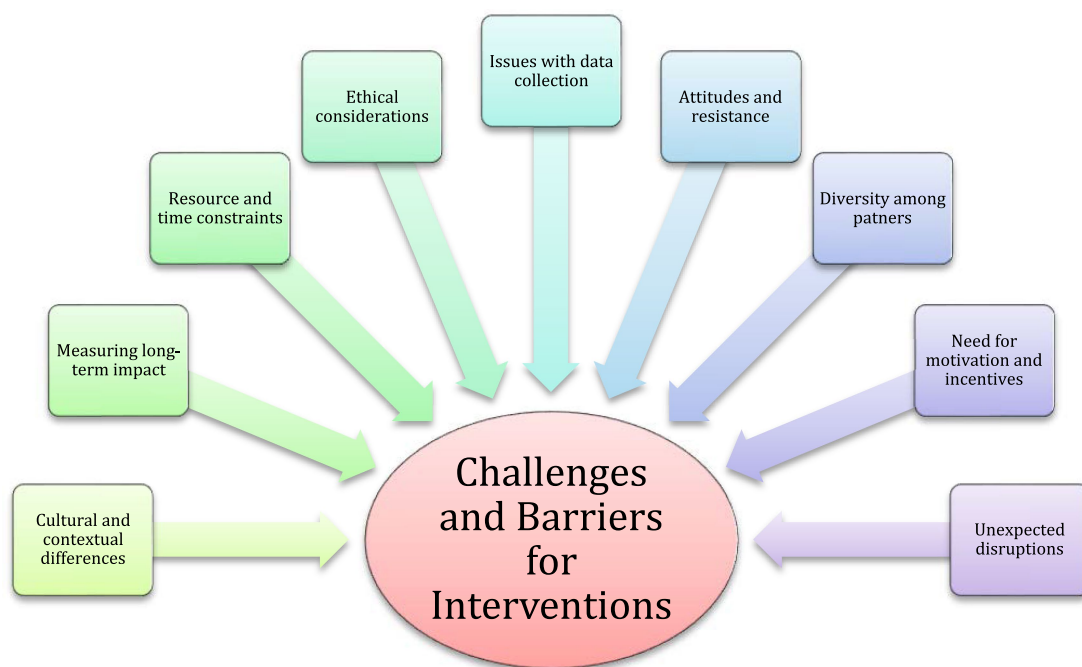


FIGURE 5
Potential challenges and barriers to interventions.

remain robust, and interventions are aligned with their expected outcomes.

The methodology provides a structured approach to intervention monitoring. It allows for flexibility in addressing unforeseen issues, such as the impact of the COVID-19 pandemic, which may affect the interventions' progress and results.

4.2 Reporting

The framework for intervention reporting follows a structured approach for documenting and analysing the project's interventions. This framework provides a comprehensive structure for reporting on interventions to ensure transparency and clarity. This structured framework ensures that intervention reporting provides a clear, detailed, and comprehensive account of each intervention's context, implementation, methodology, outcomes, and implications. This systematic approach helps the project analyse and document its interventions effectively. The key sections included in the framework are as follows:

- Title of the implementation and brief summary: introduction, introduction: background, problem definition, intervention definition, targeted behavioral change, implementation strategy, methods, and expected goals.
- Study design: setting, participants, variables, data sources and type of data, and ethical considerations.
- Analyses: descriptive data, outcomes, and main results.
- Discussion: key results, limitations, interpretation and alignment with prior research, contextual factors, and generalizability.
- Concluding remarks regarding the intervention.

4.3 Addressing potential challenges and barriers

Implementing interventions for behavioral change, especially in the context of sustainability and energy efficiency, can pose various challenges and barriers.

To address these challenges and barriers, it's essential to have a flexible and adaptive approach, regularly monitor progress, and be prepared to make adjustments when necessary. Close collaboration between scientific partners and user partners can help ensure that interventions are designed and implemented effectively, considering local conditions and requirements. Additionally, ongoing communication with participants and stakeholders is crucial to maintaining engagement and addressing concerns as they arise.

The potential challenges and risks are depicted in [Figure 5](#) and explained.

4.3.1 Achieving target population numbers

Meeting the predefined target population numbers can be challenging, especially if the intended audience is not readily accessible. Identifying and recruiting the right participants can be time-consuming and require considerable effort. In order to overcome such challenges, local organizations can be collaborated with, and their networks can be utilized for recruitment. The recruitment process can also benefit from social media and online platforms.

4.3.2 Impact of unexpected disruptions such as the COVID-19 pandemic

Disruptions such as the COVID-19 pandemic may affect participation levels, making it harder to reach the desired numbers and

impacts. Restrictions and concerns related to the pandemic could limit people's willingness to participate in interventions. Concerning this challenge, contingency plans including flexible participation options and remote communication tools for the interventions may be effective.

4.3.3 Need for motivation and incentives

Finding effective strategies to motivate and incentivise households can be challenging. People have diverse motivations and may respond differently to various incentives. Developing a standardised approach that works across different partners and samples can be complex. The referral system and a well-designed set of incentives (such as small gifts over time, with progress, and gamification of the interventions) can be used to address this challenge.

4.3.4 Diversity among partners

Implementing similar interventions by different partners with their unique samples and contexts can lead to diversity or even conflicts in the intervention strategies. Standardisation is essential, but it should also allow flexibility to adapt to local needs. Utilizing common communication channels through which participants feel comfortable to share their ideas can help alleviate this challenge. Moreover, regular meetings with participants also serves to achieve a standard and shared intervention perspective.

4.3.5 Attitudes and resistance

Households' attitudes, resistance, or negative reactions to interventions can hinder their success. Addressing resistance and concerns related to privacy and data security is crucial. Effective communication and engagement strategies are essential to mitigate these challenges. Transparent communication, explicit addressing and discussion of resistance and negative reactions are helpful regarding this challenge. In some instances, local leaders can act as mediators and encourage participation in the intervention.

4.3.6 Data collection

Collecting and post-intervention data accurately and consistently can be challenging. It's important to ensure that data collection methods align with the intervention design and follow the guidelines closely. Adherence to the research design and the guidelines is important for addressing this challenge.

4.3.7 Ethical considerations

Ethical considerations, including informed consent and data privacy, are paramount. Ensuring that participants fully understand the interventions, their implications, and how their data will be used is essential to maintain trust and minimise ethical concerns. To this end, periodic ethical reviews can also be utilized.

4.3.8 Resource and time constraints

Limited resources in terms of personnel and funding can affect the scale and scope of interventions. Ensuring that interventions are realistic within the available resources is vital. A proper intervention planning and well-designed guidelines help in addressing this challenge.

4.3.9 Measuring long-term impact

Determining the long-term impact of interventions can be challenging, as behavior change may take time to manifest. Measuring sustained energy behavior and lifestyle changes requires

extended follow-up and data collection. Regarding this challenge, post-intervention surveys and similar long-term monitoring tools can be utilized.

4.3.10 Cultural and contextual differences

Implementing interventions across diverse geographical, cultural, and organisational contexts may require adaptation to local norms and preferences. What works in one region may not work in another. Collaborating with local experts and adopting intervention messages and the general communication with respect to local values, beliefs, and norms may be useful.

5 Discussion

Projects and similar endeavours aiming for behavioral change towards environmentally friendly lifestyles implement a range of behavioral interventions to achieve them. The main objectives for these interventions are increasing the sustainability of the households through promoting more sustainable energy choices and lifestyles that aim at changes in energy behavior under real-life conditions and reviewing and systematising knowledge related to interventions for influencing human behaviors towards more sustainable energy choices.

An analysis of the literature points to gaps in terms of the existence of well-defined methods for interventions. Hence, a systematic set of guidelines have the potential to contribute to the replicability of the interventions, and the reliability of their findings. As described in the manuscript, the guidelines and the established monitoring mechanisms also enhance a better understanding of the underlying processes of the interventions. Following the guidelines also enhances the proper allocation of resources and reducing the costs of the interventions.

The interventions' design, planning, implementation, and monitoring need to be conducted systematically. A systematic framework is essential to contribute to the design, execution, and supervision of the interventions, provide standardisation and enhance collaboration with the intervention partners. In the case of a wide geographical coverage and the involvement of multiple stakeholders, intervention guidelines are crucial in ensuring that the interventions are well-coordinated and adhere to predetermined timelines.

A well-designed administrative structure with clearly defined roles is essential for successfully implementing the interventions. This structure helps ensure that the responsible staff members understand their roles and responsibilities, which is crucial for the smooth execution of the project. Ethical considerations are an indispensable component of behavioral interventions. Ethical issues can arise at any stage of the interventions, from recruitment and informed consent procedures to data collection, anonymisation of data, and data storage. Addressing ethical concerns appropriately is vital to protect the interests of participants and partners, maintain the validity of results, and ensure the project's overall success. Ethical requirements are incorporated into the guidelines and operational plan to guide ethical decision-making throughout the project.

Monitoring the interventions is critical due to the varied nature of the intervention designs and the project's wide geographical scope. The monitoring serves multiple important purposes, such as coordination, assessing validity, data collection and processing, and ethics and data management. Systematic monitoring is necessary to establish coordination between and within the interventions, ensuring that various activities align

with the project objectives. Monitoring the progress of the interventions also allows for assessing the validity of the results and conclusions drawn. Corrective actions can be taken promptly if any issues affecting the validity arise. Collection and processing of pre-intervention and post-intervention data are crucial for the intervention impact. Therefore, monitoring ensures that data is collected and utilised following the intervention designs. Ethical requirements, data privacy, and data management are essential considerations throughout the project. Monitoring helps ensure that recruitment, informed consent, data collection, anonymisation, and data storage adhere to these requirements.

The methodology for the intervention monitoring plan is adapted from general control process methodologies (Wright, 2023; Lumen Learning). It involves the key step of defining the expected mode of operation, tracking the implementation, assessing/measuring the actual performance, and comparing actual performance with the expected mode of operation: actual performance is compared with the planned mode of operation to identify any differences or deviations, determining reasons for differences/deviations, and taking actions for restoration. The utilization of control process methodology aims better resource allocation, fast adaptability, informed decision-making, and strategy adaptation.

Although the guidelines presented in this manuscript originate from the energy efficiency domain, they are applicable to environmental behavior change interventions in general.

The monitoring process is ongoing and needs to be repeated periodically. It also needs to be flexible, allowing for additional intermediate monitoring iterations as required. This adaptability ensures that the interventions remain on track and that any unforeseen issues can be addressed promptly. Regular updates are made to the planned/expected mode of operation based on the monitoring results, allowing for continuous improvement and optimisation of the interventions.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: <https://zenodo.org/records/10580655>, <https://zenodo.org/records/10579929>, <https://zenodo.org/records/10590722>, <https://zenodo.org/records/10591860>, <https://zenodo.org/records/10591860>, <https://zenodo.org/records/10580194>, and <https://zenodo.org/records/10591320>.

Ethics statement

The studies involving humans were approved by ethics committees of the research partners involved and were also

conducted according to the regulations on the data collection activities of the user partners of the ENCHANT project. For more information, please see https://enchant-project.eu/wp-content/uploads/2024/02/ENCHANT_D1.6_DMP_R1.pdf. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MB: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. MD: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Conceptualization.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was supported by a grant from the European Union's Horizon 2020 research and innovation programme (project number 957115).

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.

The handling editor GC declared a past co-authorship with the authors.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Abrahamse, W., and Steg, L. (2013). Social influence approaches to encourage resource conservation: a meta-analysis. *Glob. Environ. Chang.* 23, 1773–1785, 0959–3780. doi: 10.1016/j.gloenvcha.2013.07.029
- Alberini, A., and Bigano, A. (2015). How effective are energy-efficiency incentive programs? Evidence from Italian homeowners. *Energy Econ.* 52, S76–S85. doi: 10.1016/j.eneco.2015.08.021
- Asmare, F., Jaraitė, J., and Kažukauskas, A. (2021). The effect of descriptive information provision on electricity consumption: experimental evidence from Lithuania. *Energy Econ.* 104:105687. doi: 10.1016/j.eneco.2021.105687
- Aydin, E., Brounen, D., and Kok, N. (2018). Information provision and energy consumption: evidence from a field experiment. *Energy Econ.* 71, 403–410. doi: 10.1016/j.eneco.2018.03.008
- Barth, M., Jugert, P., and Fritzsche, I. (2016). Still underdetected – social norms and collective efficacy predict the acceptance of electric vehicles in Germany. *Transp. Res. F* 37, 64–77. doi: 10.1016/j.trf.2015.11.011
- Bekker, M. J., Cumming, T. D., Osborne, N. K., Bruining, A. M., McClean, J. I., and Leland, L. S. (2010). Encouraging electricity savings in a university residential hall through a combination of feedback, visual prompts, and incentives. *J. Appl. Behav. Anal.* 43, 327–331. doi: 10.1901/jaba.2010.43-327

- Belaïd, F., and Flambard, V. (2023). Boosting buildings energy efficiency: the impact of social norms and motivational feedback. *J. Econ. Behav. Org.* 215, 26–39. doi: 10.1016/j.jebo.2023.09.003
- Bergquist, M., Nilsson, A., and Hansla, A. (2017). Contests versus norms: implications of contest-based and norm-based intervention techniques. *Front. Psychol.* 8:2046. doi: 10.3389/fpsyg.2017.02046
- Canale, L., Ficco, G., Bertini, I., and Dell'Isola, M. (2023). About the effect of tailored energy feedback on space heating consumption and indoor air temperature in social housing buildings: an experimental investigation. *Energ. Buildings* 292:113149. doi: 10.1016/j.enbuild.2023.113149
- Cangussu, J., DeCarlo, R., and Mathur, A. (2003). Monitoring the software test process using statistical process control: a logarithmic approach. *ACM Sigsoft Softw. Eng. Notes* 28, 158–167. doi: 10.1145/949952.940093
- Castán Broto, V., and Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Glob. Environ. Chang.* 23, 92–102, 0959–3780. doi: 10.1016/j.gloenvcha.2012.07.005
- de Groot, J. I. M., Bondy, K., and Schuitema, G. (2021). Listen to others or yourself? The role of personal norms on the effectiveness of social norm interventions to change pro-environmental behaviour. *J. Environ. Psychol.* 78:101688. doi: 10.1016/j.jenvp.2021.101688
- Dharshing, S. (2017). Household dynamics of technology adoption: a spatial econometric analysis of residential solar photovoltaic (PV) systems in Germany. *Energy Res. Soc. Sci.* 23, 113–124. doi: 10.1016/j.erss.2016.10.012
- Dolan, P., Hallsworth, M., Halpern, D., King, D., Metcalfe, R., and Vlaev, I. (2012). Influencing behaviour: the mindspace way. *J. Econ. Psychol.* 33, 264–277. doi: 10.1016/j.joep.2011.10.009
- Ehret, P. J., Hodges, H. E., Kuehl, C., Brick, C., Mueller, S., and Anderson, S. E. (2021). Systematic review of household water conservation interventions using the information–motivation–behavioral skills model. *Environ. Behav.* 53, 485–519. doi: 10.1177/0013916519896868
- Ek, K., and Söderholm, P. (2008). Norms and economic motivation in the Swedish green electricity market. *Ecol. Econ.* 68, 169–182. doi: 10.1016/j.ecolecon.2008.02.013
- ENCHANT Project. Available at: <https://cordis.europa.eu/project/id/957115> (Accessed 10 October 2023)
- European Commission (EC), (2021). European Climate Pact. Available at: https://ec.europa.eu/clima/policies/eu-climate-action/pact_en (Accessed 25 October 2023).
- Fijnheer, J. D., van Oostendorp, H., Giezen, G.-J., and Veltkamp, R. C. (2021). Competition in a household energy conservation game. *Sustain. For.* 13:11991. doi: 10.3390/su132111991
- Gatersleben, B., Murrell, G., and Geusen, J. (2023). “Evaluating the effectiveness of pro-environmental behaviour change interventions: a review of reviews” in Handbook on pro-environmental behaviour change. eds. B. Gatersleben and N. Murtagh (Cheltenham, UK: Edward Elgar Publishing).
- Ghesla, C., Grieder, M., Schmitz, J., and Stadelmann, M. (2020). Pro-environmental incentives and loss aversion: a field experiment on electricity saving behaviour. *Energy Policy* 137:111131. doi: 10.1016/j.enpol.2019.111131
- Graziano, M., and Gillingham, K. (2015). Spatial patterns of solar photovoltaic system adoption: the influence of neighbors and the built environment. *J. Econ. Geogr.* 15, 815–839. doi: 10.1093/jeg/lbu036
- Hales, S., Leshar-Trevino, A., Ford, N., Maher, D., Ramsay, A., and Tran, N. (2016). Reporting guidelines for implementation and operational research. *Bull. World Health Org.* 94, 58–64. doi: 10.2471/BLT.15.167585
- Hayes, S. C., and Cone, J. D. (1981). Reduction of residential consumption of electricity through simple monthly feedback. *J. Appl. Behav. Anal.* 14, 81–88. doi: 10.1901/jaba.1981.14-81
- Helferich, M., Thøgersen, J., and Bergquist, M. (2023). Direct and mediated impacts of social norms on pro-environmental behaviour. *Glob. Environ. Chang.* 80:102680. doi: 10.1016/j.gloenvcha.2023.102680
- Hewitt, E. L., Wang, Y., Eck, A., and Tonjes, D. J. (2023). Keeping up with my neighbors: the influence of social norm feedback interventions on recycling behavior in urban multifamily buildings. Resources, Conservation & Recycling. *Advances* 18:200156. doi: 10.1016/j.rcradv.2023.200156
- IPCC. (2021). Climate change 2021: the physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [Online] Available at: <https://www.ipcc.ch/report/ar6/wg1/#FullReport> (Accessed 5 November 2024).
- Jakhar, S. K. (2017). Stakeholder engagement and environmental practice adoption: the mediating role of process management practices. *Sust. Dev.* 25, 92–110. doi: 10.1002/sd.1644
- Ji, Z., Gong, Y., Li, Y., and Sun, Y. (2023). Effects of monetary and nonmonetary incentives in individual low-carbon behavior rewarding system on recycling behaviors: the role of perceived environmental responsibility. *Sustain. Prod. Consum.* 38, 90–103. doi: 10.1016/j.spc.2023.03.026
- Kacperski, C., Bielig, M., Klingert, S., and Kutzner, F. (2023). For the climate, my friends, or my region? An experimental field trial for prosumer engagement with peer-to-peer energy trading in Austria. *Energy Res. Soc. Sci.* 97:103000. doi: 10.1016/j.erss.2023.103000
- Komatsu, H., and Nishio, K. (2015). An experimental study on motivational change for electricity conservation by normative messages. *Appl. Energy* 158, 35–43. doi: 10.1016/j.apenergy.2015.08.029
- Konis, K., Orosz, M., and Sintov, N. (2016). A window into occupant-driven energy outcomes: leveraging sub-metering infrastructure to examine psychosocial factors driving long-term outcomes of short-term competition-based energy interventions. *Energ. Buildings* 116, 206–217. doi: 10.1016/j.enbuild.2016.01.005
- Kramer, J., and Petzoldt, T. (2023). Environmental, altruistic, or monetary benefits? A longitudinal online experiment on how framed behavioral consequences affect self-reported eco-driving of German vehicle owners. *Transport. Res. F: Traffic Psychol. Behav.* 93, 204–221. doi: 10.1016/j.trf.2023.01.006
- Kwan, C. L. (2012). Influence of local environmental, social, economic and political variables on the spatial distribution of residential solar PV arrays across the United States. *Energy Policy* 47, 332–344. doi: 10.1016/j.enpol.2012.04.074
- Legault, L., Bird, S., Powers, S. E., Sherman, A., Schay, A., Hou, D. Q., et al. (2020). Impact of a motivational intervention and interactive feedback on electricity and water consumption: a Smart housing field experiment. *Environ. Behav.* 52, 666–692. doi: 10.1177/0013916518811433
- Liu, N., Luo, X., Liu, X., and Xing, M. (2023). Impacts of normative information on college students' energy-saving intentions and behaviors in the dormitory. *Energy Built Environ.*, 2666–1233. doi: 10.1016/j.enbenv.2023.12.001
- Mäkkivierikko, A., Siepelmeyer, H., Shahrokni, H., Enarsson, D., and Kordas, O. (2023). Reducing electricity peak loads through ‘pause hours’—a community-based behavioural demand response approach. *J. Clean. Prod.* 408:137064. doi: 10.1016/j.jclepro.2023.137064
- Michie, S., van Stralen, M. M., and West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement. Sci.* 6:42. doi: 10.1186/1748-5908-6-42
- Mundaca, L., Rotmann, S., Ashby, K., Karlin, B., Butler, D., Sequeira, M. M., et al. (2023). Hard-to-reach energy users: an ex-post cross-country assessment of behavioural-oriented interventions. *Energy Res. Soc. Sci.* 104:103205. doi: 10.1016/j.erss.2023.103205
- Neumann, R., and Mehlkop, G. (2020). Framing electricity plan choices to enhance green energy usage: a choice experiment with panel data from Germany. *Energy Res. Soc. Sci.* 70:101741. doi: 10.1016/j.erss.2020.101741
- Nockur, L., and Pfattheicher, S. (2020). Fostering sustainable behavior through group competition. *J. Environ. Psychol.* 71:101493. doi: 10.1016/j.jenvp.2020.101493
- OECD (2019). Tools and ethics for applied behavioural insights: the BASIC toolkit. Paris: OECD Publishing.
- Petersen, J. E., Shunturov, V., Janda, K., Platt, G., and Weinberger, K. (2007). Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. *Int. J. Sustain. High. Educ.* 8, 16–33. doi: 10.1108/14676370710717562
- Pourmirza, S., Peters, S., Dijkman, R., and Grefen, P. (2017). A systematic literature review on the architecture of business process management systems. *Inf. Syst.* 66, 43–58. doi: 10.1016/j.is.2017.01.007
- Rajapaksa, D., Gifford, R., Torgler, B., Garcia-Valiñas, M., Athukorala, W., Managi, S., et al. (2019). Do monetary and non-monetary incentives influence environmental attitudes and behavior? Evidence from an experimental analysis. *Resour. Conserv. Recycl.* 149, 168–176. doi: 10.1016/j.resconrec.2019.05.034
- Rau, H., Nicolai, S., and Stoll-Kleemann, S. (2022). A systematic review to assess the evidence-based effectiveness, content, and success factors of behavior change interventions for enhancing pro-environmental behavior in individuals. *Front. Psychol.* 13:901927. doi: 10.3389/fpsyg.2022.901927
- Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., and Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychol. Sci.* 18, 429–434. doi: 10.1111/j.1467-9280.2007.01917.x
- Schwartz, D., Bruine de Bruin, W., Fischhoff, B., and Lave, L. (2015). Advertising energy saving programs: the potential environmental cost of emphasizing monetary savings. *J. Exp. Psychol. Appl.* 21, 158–166. doi: 10.1037/xap0000042
- Shen, M., Lu, Y., Kua, H. W., and Cui, Q. (2020a). Eco-feedback delivering methods and psychological attributes shaping household energy consumption: evidence from intervention program in Hangzhou, China. *J. Clean. Prod.* 265:121755. doi: 10.1016/j.jclepro.2020.121755
- Shen, M., Lu, Y., Kua, H. W., and Cui, Q. (2020b). Prediction of household electricity consumption and effectiveness of concerted intervention strategies based on occupant behaviour and personality traits. *Renew. Sustain. Energy Rev.* 127, 109839–100321. doi: 10.1016/j.rser.2020.109839
- Sloot, D., and Scheibehenne, B. (2022). Understanding the financial incentive conundrum: a meta-analysis of the effectiveness of financial incentive interventions in promoting energy conservation behaviour. *Renew. Sust. Energy Rev.* 168:112761. doi: 10.1016/j.rser.2022.112761
- Staddon, S. C., Cycil, C., Goulden, M., Leygue, C., and Spence, A. (2016). Intervening to change behaviour and save energy in the workplace: a systematic review of available evidence. *Energy Res. Soc. Sci.* 17, 30–51. doi: 10.1016/j.erss.2016.03.027
- Steinhorst, J., and Klöckner, C. A. (2017). Effects of monetary versus environmental information framing: implications for long-term pro-environmental behavior and intrinsic motivation. *Environ. Behav.* 50, 997–1031. doi: 10.1177/0013916517725371

- Sundnes, K. O. (2014a). Operational planning for a specific intervention. *Scand. J. Public Health* 42, 119–122. doi: 10.1177/1403494813515120
- Sundnes, K. O. (2014b). Selection of responses and interventions. *Scand. J. Public Health* 42, 113–118. doi: 10.1177/1403494813515118
- Sundnes, K. O. (2014c). Implementation, execution, and completion of projects. *Scand. J. Public Health* 42, 123–129. doi: 10.1177/1403494813515121
- Syropoulos, S., Markowitz, E. M., Demarest, B., and Shrum, T. (2023). A letter to future generations: examining the effectiveness of an intergenerational framing intervention. *J. Environ. Psychol.* 90:102074. doi: 10.1016/j.jenvp.2023.102074
- van Valkengoed, A. M., Abrahamse, W., and Steg, L. (2022). To select effective interventions for pro-environmental behaviour change, we need to consider determinants of behaviour. *Nat. Hum. Behav.* 6, 1482–1492. doi: 10.1038/s41562-022-01473-w
- Wang, B., Deng, N., Li, H., Zhao, W., Liu, J., and Wang, Z. (2021). Effect and mechanism of monetary incentives and moral suasion on residential peak-hour electricity usage. *Technol. Forecast. Soc. Change* 169:120792. doi: 10.1016/j.techfore.2021.120792
- Wright, T. (2023). CSO's guide to effective strategic management process. Available at: <https://www.cascade.app/blog/strategic-management-process> (Accessed November 1, 2024)
- Xie, C., Ding, H., Zhang, H., Yuan, J., Su, S., and Tang, M. (2021). Exploring the psychological mechanism underlying the relationship between organizational interventions and employees' energy-saving behaviors. *Energy Policy* 156, 112411–112415. doi: 10.1016/j.enpol.2021.112411
- Xu, X. J., Arpan, L. M., and Chen, C. F. (2015). The moderating role of individual differences in responses to benefit and temporal framing of messages promoting residential energy saving. *J. Environ. Psychol.* 44, 95–108. doi: 10.1016/j.jenvp.2015.09.004
- Xu, Q., Lu, Y., Hwang, B., and Kua, H. W. (2021). Reducing residential energy consumption through a marketized behavioral intervention: the approach of household energy saving option (HESO). *Energy Buildings* 232, 110621–117788. doi: 10.1016/j.enbuild.2020.110621
- Xu, L., Zhang, X., and Ling, M. (2018). Pro-environmental spillover under environmental appeals and monetary incentives: evidence from an intervention study on household waste separation. *J. Environ. Psychol.* 60, 27–33. doi: 10.1016/j.jenvp.2018.10.003

Appendix

TABLE A1 Sample intervention monitoring checklist template.

Partners: Intervention: Date:													
	Pre-intervention					Implementation			Post-intervention				
	Recruitment	Randomization		Pre-intervention data collection		Intervention kick-off		Implementation of the intervention	Post-intervention data collection			Intervention Closure	
	Targeted number of participants vs actual recruited are compared	Experimental group the intervention is implemented is formed	A control group without any intervention is formed	The data collection method is planned	Designed data to be collected vs. actual data collected are compared	Intervention is started on time	Participants and involved parties are informed about the procedures	Guidelines and Operational Plan followed according to the intervention designs and RCT research protocol and the timelines	The data collection method is as planned and is confirmed	Planned data to be collected vs. actual data collected are compared	Compatibility with pre-intervention data is checked	Intervention is closed on time	Any delay/ deviations affecting intervention closure are checked
Deviation from plan													
Ethical considerations													



OPEN ACCESS

EDITED BY

Giuseppe Carrus,
Roma Tre University, Italy

REVIEWED BY

Dorina Rajanen,
University of Oulu, Finland
Heidi Gibson,
Smithsonian Institution, United States

*CORRESPONDENCE

Kristoffer Skomsøy Fjællingsdal
✉ kristoffer.fjallingsdal@ntnu.no

RECEIVED 09 April 2024

ACCEPTED 31 December 2024

PUBLISHED 21 January 2025

CITATION

Fjællingsdal KS (2025) Expanding the green gaming horizon: a conceptual analysis of and proposed guidelines for upscaling environmental game usage in climate education. *Front. Psychol.* 15:1414705. doi: 10.3389/fpsyg.2024.1414705

COPYRIGHT

© 2025 Fjællingsdal. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Expanding the green gaming horizon: a conceptual analysis of and proposed guidelines for upscaling environmental game usage in climate education

Kristoffer Skomsøy Fjællingsdal*

Department of Psychology, Norwegian University of Science and Technology, Trondheim, Norway

Despite the now unequivocal notion that climate change is driven by anthropogenic activity, communication between concerned climate scientists and laypeople about the severity of the issue is still muddy. Although creative and more approachable venues of communication to climate change and sustainability issues are being explored more regularly than before, there is still room for improvement and upscaling in the attempts to link scientists and laypeople together in the understanding of these outstanding issues. This also applies to the field of environmental gaming, which has become more popular in the recent decade. Despite this increasing popularity, however, most environmental gaming studies exist as small-scale pilot studies that often result in generating limited, albeit promising results in terms of increasing awareness and knowledge around environmental topics. This article explores the use of games in climate- and sustainability education and provides a set of assisting guidelines to ease the process of using games as communication tools about these pressing issues, as well as providing advice on how to upscale environmental gaming from a set of limited pilot studies.

KEYWORDS

environmental games, serious games, upscaling, sustainability, science communication

1 Introduction

Climate change, biodiversity decline, the energy crisis—these represent just a handful of the wicked problems that the world is facing today (IPBES, 2019; IPCC, 2023), and the science showcasing the role of anthropogenic activity in this is unequivocal (Somerville and Hassol, 2011). Paradoxically, it is also well-known that science communicators and scholars alike are struggling to engage meaningfully with laypeople in terms of showcasing exactly how dire these wicked problems truly are (e.g., McBean and Hengeveld, 2000; Moser, 2016; Wang and Coren, 2024, p. 5) and why they need public action to be circumvented. As a result, the need for creative approaches to environmental communication is growing (e.g., Illingworth, 2020; Redfern et al., 2016). One such approach comes in the form of *environmental games* (sometimes referred to as green games, climate games or sustainability games), which have the explicit purpose of teaching, communicating or otherwise informing their players of general as well as specific issues that fall under the umbrella of anthropogenic climate change.

In 2015, embarking on the road toward investigating the transformative potentials in environmental games as part of his PhD (Fjællingsdal, 2021), the author sent an email to Jesse Schell, game designer and author of the book “The Art of Game Design: A Book of Lenses”, asking his opinion as to why games about the climate and the environment are less attractive or popular than the more conventional or commercially successful games that were available on store shelves. This question is important due to two main reasons; firstly, due to the current state the environmental gaming market, which had bloomed significantly in the years prior (Reckien and Eisenack, 2013) despite failing to enter mainstream gaming, and secondly, the steadily increasing popularity of gaming (ESA, 2015)—a rise that continues to this day (ESA, 2023). His response was quick and to the point: (1) many environmental games are of inadequate quality, and (2) they are harder to make due to having more constraints than conventional games—or, in his words: “Making a delicious pastry is difficult; making a delicious pastry that cures cancer is much harder” (J. Schell, personal communication, September 11, 2015). It is now 9 years later, and a recent article shows that despite developments in the serious gaming field, we are still left ‘paddling in the shallows’ in terms of tapping into the deeper potential in games for educational or transformational purposes (Heron and Crabb, 2023). This also holds true for the gradually emerging field of environmental games, although they have been subjects of research since at least the 1980s (Baba et al., 1984; Robinson and Ausubel, 1983).

There appears to be a notion among game scholars and -researchers that games both can and should be utilized in educational contexts such as classroom activities and curricula or other organized initiatives—a notion that goes back at least several decades (e.g., Abt, 1970). Despite this, as well as the increasing fervor, activity, and contributions that can be observed among the gaming field’s many fandoms (Heron and Crabb, 2023), meta-analyses across a span of several years on the general effectiveness of games as educational tools tend to yield mixed or inconclusive results (e.g., Arztmann et al., 2023; Girard et al., 2012; Talan et al., 2020) even though they are often shown to be more motivating, engaging, accessible and fun to use than other forms of educational tools (Gee, 2005; Jennett et al., 2008; Ryan et al., 2006). For environmental games specifically, few such analyses appear to even exist—something which can largely be attributed to an overall lack of empirical research on them (e.g., Hallinger et al., 2020). Although these analyses on the effectiveness of environmental games have generally yielded promising results (Boncu et al., 2022; Janakiraman et al., 2021a,b; Rajanen and Rajanen, 2019), they still have significant barriers working against their use (Fernández Galeote et al., 2021) and upscaling—that is, their potential for being used for purposes other than lone-standing pilot studies. Heavily inspired by the design and structure of Gifford’s (2011) seminal work on psychological barriers against pro-environmental behavior, this paper seeks to address barriers against the use of games in climate- and sustainability education, with the goal being to create a set of proposed guidelines that can illuminate how games can be used to maximize their effectiveness as communication tools about climate change and its underlying facets. These guidelines are intended to help future researchers and practitioners (e.g., teachers, pedagogues, and environmental gaming enthusiasts and -hobbyists) who wish to use environmental games in their projects,

provide a realistic picture of how complex yet gratifying gaming interventions can be, as well as underline what can be considered necessities to upscale environmental gaming research beyond limited pilot studies—an issue that has proven to be pervasive across the environmental gaming research literature (Fernández Galeote et al., 2021).

2 Environmental games—What are they, and how can they be used?

As previously stated, an *environmental game* can be defined as a subgenre of *serious game*—a game that seeks to do more than just entertain its players (Abt, 1970). Environmental games seek to educate, inform, or otherwise communicate about general or specific issues relating to climate change and other topics within the frame of sustainability, as well as build awareness and motivate people to act against climate change (Ouariachi et al., 2018, p. 1). They come in both digital (computer-, console- or browser-based games) and analog formats (board- and card-based games), as well as varying degrees of complexity. Early examples of digital environmental games include the environmental policy game *Balance of the Planet* (Crawford, 1990), and the planetary development game *SimEarth* (Wright, 1990)—both containing elements that can be found in newer digital environmental games such as *Fate of the World* (Red Redemption, 2011). Social dilemmas, some of which constitute the root of the environmental issues we are facing (Dawes, 1980), are also subjects of environmental games. One example includes the *Commons* game (Powers, 1987) which illustrates how Garrett Hardin’s *Tragedy of the Commons* operates—a theoretical situation in which different actors are provided a shared resource and need to co-manage it (Hardin, 1968). Another example—also revolving around the core tenets of Hardin’s *Tragedy of the Commons*—is the hybrid digital-/board game *Fish Banks* (Meadows, 1986), where the players must operate their own competing fishing companies while simultaneously trying to prevent the fish stocks from depleting entirely. Some environmental games are simplistic, revolving around basic actions such as reducing energy use in the home (Klöckner, 2015, p. 199), while others are developing into large-scale, complex climate simulators in close collaboration between climate scientists, professional game designers, and the players themselves (e.g., *Eco*, by Strange Loop Games or the Corporation for Public Broadcasting-funded *World Without Oil* project). Some environmental games follow a classic instrumental design approach where they provide didactic content to the player about how to behave sustainably, whereas others utilize a humanistic design approach where the players are given more agency to determine what constitutes environmental issues and how to counteract them (Spanellis et al., 2024). Furthermore, some environmental games are commercially available off-the-shelf (e.g., *Keep Cool* by Eisenack and Petschel-Held, 2004 and *Fate of the World*) whereas others exist solely as temporary pilots for scientific studies and are not available to the general population.

Despite the overall lack of large-scale empirical research on the use of environmental games, they are generally shown to be capable of breaking down some of the psychological barriers surrounding pro-environmental behavior as described in Gifford (2011). These

include (a) emphasizing climate change as a local and personal risk, (b) encouraging more affective and experimental solutions to the issue, (c) appealing to relevant social groups, (d) emphasizing which policies can lead to immediate action, and (e) focusing on environmental goals and outcomes that hold long-term value (van der Linden et al., 2015). Environmental games are shown to reduce the psychological distance to environmental issues and making them appear closer and more relevant to the individual by holding the player accountable for their impact on the in-game world (Fjællingsdal and Klöckner, 2019). In many ways, sophisticated environmental games can be considered *microworlds*—simplified representations of reality containing artifacts that the player can freely explore, experiment with, and understand (Egenfeldt-Nielsen, 2006). Through learning in this manner, players are allowed to make mistakes and explore the effects of their own manipulations and impact, without having to fear real-life consequences (McGonigal, 2011, p. 303). Some games, such as the board-based *Evolution: Climate* (Crapuchettes, 2016), also utilize affective components that can generate empathy with animals or other living things that can be negatively affected by a drastically warmer or colder climate. Others allow their players to experiment with various environmental policies to see how it affects the state of the in-game planet, such as *Fate of the World* (Red Redemption, 2011). Lastly, some games allow the expression of alternate worldviews, political and religious affiliations, and motivations by situating the players in shared social dilemmas (Fjællingsdal and Klöckner, 2019, 2020; Flood et al., 2018; Wu and Lee, 2015).

3 Methods

To explore the concept of environmental games and generate proposed guidelines for their upscaling, a conceptual analysis was conducted (inspired by Ho and Sommers, 2013). Although the chosen conceptual analysis framework consists of 8 steps, 1 of them (identification of antecedents and outcomes) was omitted from this paper due to being more relevant for clinical or medical fields of study. The chosen conceptual analysis framework therefore consists of 7 steps: (1) concept selection, (2) analysis purpose, (3) concept use identification, (4) identifying defining attributes, (5) identifying empirical referents, (6) identifying model cases, and (7) identifying borderline, related or contrary cases. A preliminary literature search for the key terms “environmental games”, “sustainability games” and individual game names (e.g., “Eco”) was conducted in Google Scholar to provide insight into the concept of environmental games, establish a clear purpose for analyzing them in light of identifying barriers toward their upscaling, and gain an understanding of the defining attributes of environmental games and how they are used in empirical research (Steps 1–5). Additionally, a parallel search for environmental games on the gaming aggregates Steam and BoardGameGeek was also performed to identify representative environmental games for a conceptual analysis (Steps 6–7). The literature search revealed 52 games with an environmental focus, and that the number of new environmental games grew considerably since the early 2000s (Reckien and Eisenack, 2013). This trend also appears to extend to the quality, rigor, and frequency of scientific research on the topic (Fernández Galeote et al., 2021; Hallinger et al., 2020). The

literature review also showed that environmental games remain a niche form of serious game with few empirical applications (Hallinger et al., 2020), and even fewer interventions on a larger scale than pilot studies (Fernández Galeote et al., 2021)—one notable exception being the World Without Oil project where individuals across the world contributed ideas on how to solve a fictional global oil shortage crisis (McGonigal, 2011). Recurring games discovered in the literature search (e.g., *Eco* and *Keep Cool*) were then cross-checked with their Steam and BoardGameGeek pages where the games were commercially available, and their overall user ratings were used as a basis for inclusion in this conceptual analysis. Based on the literature and games explored, a set of proposed guidelines has been generated and will be explored further in the following section.

4 Using and upscaling environmental games—A proposed set of guidelines

In the same vein as other forms of serious games, environmental games have a range of issues and barriers surrounding their implementation by academics and practitioners wishing to tap into their inherent potential as communication and learning tools. Several of these issues and barriers can be directly related to the overall lack of upscaled gaming interventions that are sorely needed to advance the field today. The following section is dedicated to illuminating and exploring some of these issues and barriers, as well as relating them to the overarching issue of scalability. Although this list is not likely to be entirely exhaustive, it does serve as an important early step toward the upscaling of environmental games as a creative, engaging, and approachable way to learn about climate and sustainability topics.

4.1 Environmental games and the social component—By humans, for humans

The social component of game design and -use is inevitable. As Schell (2010) shows, each step of both game design and gameplay involves deep consideration and reflection from the designers themselves and what ideas or visions they have for how the game is supposed to look, as well as how the players eventually receive, decode and appreciate the designers' vision. Any successful game-based learning intervention therefore starts with good preparation and surveying which games are available on the market, as well as what they involve in terms of their contents and playtime, complexity, player-, software- and hardware requirements, and relevance to the subject that is to be taught. Failing to conduct a solid survey of these factors could result in a suboptimal gameplay experience, a missing link between what the game can teach and the overall aim of the game-based learning intervention, or even a possibility that the game is unable to be played at all due to limitations in the software or hardware that the games require. As such, when choosing a suitable green game for a given intervention, it is vital to understand the relevance and complexity of the game's contents in relation to its players as well as its suitability for the intervention's framework in terms

of gameplay location, time use, and other contextually relevant factors. Although there is an overreliance on the inherent, almost magical properties of a game to teach about its subject matter (Gunter et al., 2007), a considerable amount of work is involved in preparing and conducting the intervention itself. As it stands, there is a likelihood that pilot studies that underestimate or otherwise fail to acknowledge the preparatory stages of gaming interventions are likely to yield disappointing research findings, as well as resulting in a lack of continued interest in game-based learning or expanding the gaming intervention past its pilot stage. This section is therefore intended to address known issues and pitfalls in the use of game-based interventions, to improve the outcomes and increase the likelihood of moving these interventions from pilots into upscaled environmental gaming research projects.

4.1.1 Teamwork is key

Gaming interventions often involve significant preparatory work—the field needs to be surveyed to find a game that is appropriate for the intervention, gaming licenses or physical games must be acquired, rules must be examined and understood, software and hardware checks must be conducted, physical spaces and other necessary requirements need to be booked in order for the intervention to take place, a research design needs to be decided upon if research on the intervention is intended, players must be recruited, expectations and goals for the game must be clarified, and significant gameplay dates need to be set. Already, the list of preparatory work might appear daunting—but it is hardly exhaustive. Individual environmental games have individual requirements, and some of them have been shown to take a significant amount of time to complete (Fjællingsdal and Klöckner, 2019) or even explain to the players (Fjællingsdal and Klöckner, 2020). As such, it is recommended that gaming interventions are planned and organized by dedicated groups with relevant expertise, and preferably featuring instructors or facilitators who are familiar with the game and its mechanics from before (Flood et al., 2018). Early engagement with a team of relevant actors (e.g., teachers and the IT department at a school) (Skaug et al., 2020, p. 161) or local volunteer gaming centers or hobby groups can ease the planning process of gaming interventions, as well as providing potential insight into expectations and preconceptions surrounding the intervention itself. It is also recommended that the team conducts some gameplay sessions beforehand—both to get acquainted with how the game plays and works, but also to gain inspiration as to how the game can be used to maximize its learning potential.

4.1.2 Using games co-developed by professional game designers and climate experts

While the gaming market is seeing an influx of new games with environmental themes (Hallinger et al., 2020; Reckien and Eisenack, 2013), only a select few of them are developed as collaborations between professional game designers and trained academics. Fewer still are those games who also end up receiving good or decent reviews on some of the most widely used online gaming platforms such as Steam and Metacritic. Examples of these select few include digital games such as *Fate of the World* (Red Redemption, 2011) and *Eco* (Strange Loop Games, 2020), and

board games such as *Keep Cool* (Eisenack and Petschel-Held, 2004). As mentioned earlier in this article, Jesse Schell stated that the main reasons for why environmental games might fail boil down to (1) their overall lack of quality, and (2) having more constraints due to their more “serious” nature. Although several academics tend to develop their own games for the purpose of educating or generating awareness of certain issues, they often lack the creative rigor and *gameful* experiences that only a career in game design can hope to enable (Theodosiou and Karasavvidis, 2015)—*gamefulness* referring to the psychological state in which one playfully or joyfully approaches in-game goals and tasks as non-trivial obstacles that need to be overcome (Landers et al., 2019). As such, it is recommended that games co-developed by professional game designers and academic scholars should be utilized more. Dedicated researchers wishing to use such games are encouraged to survey the field thoroughly, using the tagging systems on larger gaming aggregates such as Steam or BoardGameGeek to locate games with environmental themes, reading reviews of relevant games on Metacritic to gain insight both from professional and public reviewers, and engaging with forums and fandoms dedicated to the game in question.

4.1.3 The target audience

Most games have a target audience—the type of player that the game is intended for. Although game designers tailor their games for selected people (Schell, 2010, p. 97), formal designation of the target audience by rating boards such as the Entertainment Software Rating Board (ESRB) is also required, which normally uses demographic factors (e.g., age) and the level of the game’s mature content (e.g., violence or language use) as a basis (ESRB, 2024). These rating scales, however, generally concern the suitability of the game’s content, not complexity, for the players based on their psychological maturity. More recently, websites such as BoardGameGeek.com has begun introducing complexity scales (otherwise known as *weight*) which detail factors such as the difficulty of the game’s rulebook, how long the gameplay time is, the amount of time spent planning one’s actions in the game, whether the game is luck- or skill-based, the amount of technical skill required to play, and how many replays are required in order to fully understand the complexities of the game (BoardGameGeek.com, 2024). For digital games, websites such as HowLongToBeat.com provide an overview of how long previous players of the game, on average, have taken to beat specific games given specific scenarios, which makes it easier to choose an appropriate game for timed interventions particularly. Using such guides before a gaming intervention simplifies the process of choosing appropriate games, even though they are seldomly operationalized—seemingly relying more on player feedback than scientific evaluation. It has been shown, however, that the often-daunting complexity of games can be alienating (McNamara et al., 2009), thus highlighting the need for such scales. As an example, *Eco*—although being met with critical acclaim—has been shown to be quite labor-intensive, sometimes requiring up to 30 real-life days of gameplay to meet the in-game goal (Fjællingsdal and Klöckner, 2019). On the opposite end of the scale, other environmental games are very simplistic and aimed for younger audiences, meaning they take little time to complete and feature

little complexity (Koehler et al., 2017). For a dedicated researcher wishing to do gaming interventions, understanding the connection between game complexity, game content and the target audience is therefore important. Failure to use an appropriate game for a specific audience could, in many cases, lead to frustration, boredom, and disappointing research findings. This is concurrent with the notion that intrinsic motivation to act arises from an ideal relationship between the complexity of a task and the skill level of the person performing said task—the so-called *zone of optimal experience* (Csikszentmihalyi, 1990).

4.1.4 Game skepticism

Although environmental games are not a new concept, the small-scale empirical evidence on their effectiveness (e.g., Hallinger et al., 2020) as well as varying degrees of complexity, unfamiliarity and often unclear connection to mandatory school curricula (Klopfer et al., 2009) have exerted a certain skepticism among teachers, students, and parents alike in terms of using them—especially in classroom settings or pilot studies where serious games are generally meant to be played. In a classroom setting, for example, games have been frowned upon for their lack of graphical quality (Rice, 2006), confusing or complex user interfaces (Fjællingsdal and Klöckner, 2017), low production values and insufficient gameplay quality (Illingworth and Wake, 2019). Some educational games are also scrutinized for being unrealistic or failing to depict the full complexity of environmental issues, although past research has shown that players are often capable of discounting the game's lack of realism (Feinstein and Cannon, 2002; Norman et al., 2012) as well as asking critical questions as to why some things work in the game but not in real life (Schell, 2010). This especially appears to be the case for more experienced players who are familiar with realistic breaches in games (Fjællingsdal and Klöckner, 2019). However, much of the criticism is still warranted due to the aftermath of the influx of low-quality e-learning and digital education tools and -games that began flooding the market in the early 1990s. Much has since changed for the better—also in the environmental gaming field (Reckien and Eisenack, 2013) but dispelling the prevalent skepticism toward games is still a complicated matter. Game skepticism furthermore becomes a negative spiral in that it discourages their use, which in turn ensures that empirical investigations into their effectiveness will remain low. One possible solution to this is to engage with the relevant stakeholders (e.g., teachers, students, and parents if the game is to be used in a classroom setting) at an early stage in the gaming intervention—weighing the interest toward using games and acknowledging any barriers toward using them. Research has shown that allowing skeptical teachers to engage meaningfully with an educational game is both capable of (1) dispelling some of the existing skepticism, as well as (2) allowing for an open-ended discussion where any remaining concerns surrounding the use of games in a specific setting can be addressed and clarified (Gaudelli and Taylor, 2011). This research has also shown that teachers are generally cautious of using educational games because of the way in which they present and trivialize their content, take too much time to plan and implement, and that they feel that games can never “outperform them” as teachers. Acknowledging such insecurities and finding solutions for them at an early stage of

an environmental gaming intervention is therefore recommended to ease the adoption process and fitting the chosen game into the curriculum. One way in which to do this is through the organization of short workshops before the main intervention itself, where skeptical stakeholders can engage with the game and voice any remaining concerns they might have.

4.2 Learning objectives and openness to new horizons

Another core issue with environmental games that prevents their upscaling is the relative newness of their application as educational tools, despite having been formally included in research since at least the 1980s. Combined with the fact that most educational institutions have a clear demand that all of their institutional activities must in some way, shape or form be connected to the mandatory school curriculum (Skaug et al., 2020, p. 73), implementation of games in educational settings can be challenging. This can also lead to games being used as convenient and colorful wrapping for otherwise boring or didactic content (Galarneau, 2005), meaning that many educational games (and not just environmental ones) stand the risk of simply becoming digitized textbooks rather than the “magical” education tools that serious gaming literature often paints them as. Although this approach might be decent, as Galarneau observes, for learning material that is otherwise mundane and boring or requiring repeated practice to fully comprehend, it is not likely to be a very engaging means of communicating about dramatic and complex issues such as climate change or biodiversity loss.

4.2.1 “Beyond” the curriculum

As previously stated, games need to fit the curriculum if they are to be utilized in conventional educational settings such as schools. It is worth noting that in some of these institutions, although the curriculum contains clearly stated learning objectives, there is still a significant amount of wiggle room in terms of using games as cultural expressions within the classroom setting (Skaug et al., 2020, p. 73). And while the notion today is that games need to adhere vehemently to the curriculum, it is possible to argue that they can go well beyond it too. Imagine, for example, a situation in which a biology curriculum states that the learners need to obtain a basic understanding of how different species relate to each other in an ecosystem. The relationship between different species in a frail ecosystem is a core component of the digital game *Eco* (Möring and Schneider, 2024, p. 209), which has been mentioned earlier in this paper. But the game also situates this theme within a much larger context—for example, the relationship between basic physiological human needs and animal products, the need to gather materials necessary for the survival of other species in order to build necessary infrastructure, the effect of anthropogenic emissions on nature, as well as the overarching and highly important (albeit fantastical) scenario that an asteroid is set to hit and severely damage the in-game planet in 30 real-life days (Fjællingsdal and Klöckner, 2019). The game therefore does not statically communicate the complexity of the relationship between species with text; it rather gives the player

agency in what happens and why, as well as how it impacts the game world—thus generating a form of *designed experience* where emotional pathways are formed between the in-game action and the in-game consequence of that action (Wu and Lee, 2015). This form of imparting knowledge (or persuasion) is known as *procedural rhetoric*—a practice of using processes and rules rather than the more conventional and static text and images; altogether, a promising communication approach showcasing how things work or are connected (Bogost, 2008, p. 125). Games also do not necessarily need to be explicitly educational to form interesting discussion backdrops about environmental topics; even conventional, highly lauded, and off-the-shelf games have tackled the topic before (Blake et al., 2024). One is the 1997 PlayStation game *Final Fantasy 7* (Square, 1997) where the player is set to fight against a large global energy company which threatens to annihilate the planet by drawing out its life energy. Although this is not the only goal in the game, it represents a significant part of the background for its main storyline, and parallels can certainly be drawn to the ongoing real-life energy crisis. Another example is the digital game *Okami* (Capcom, 2007), where some of the mechanics in the game revolve around restoring twisted, damaged nature with magical brushstrokes. Environmental themes can also be found in the digital game *Oddworld: Stranger's Wrath* (Oddworld Inhabitants, 2005), where the player is set to combat an entity responsible for species extinction and monopolization of natural resources. Although these games are only tangentially environmental, they can still serve as a more approachable introduction or backdrop to contemporary climate issues than a conventional textbook and could potentially represent an answer to the call for more engaging means of pro-environmental communication (Illingworth, 2020). It has also been found that, while explicitly educational environmental games might be less capable of reaching wider audiences, conventional off-the-shelf games often contain educational properties about nature elements such as wildlife species (Crowley et al., 2021)—meaning that they can form a solid foundation for discussion and reflection when used by a creative educator or practitioner.

4.2.2 Knowledge is power—But not action

Knowledge about environmental issues is an important, yet insufficient component of pro-environmental behavior (Sturgis and Allum, 2004). This is crucial in an upscaling perspective, as environmental games are primarily intended to motivate climate action (Ouariachi et al., 2018, p. 1). Yet—again paradoxically—the primary goal of environmental games often tends to be knowledge provision in some form. As a result, as Galarneau (2005) has previously observed, they are often perceived as digital copies of conventional textbooks—that is, not very engaging and not necessarily a good alternative to traditional teaching methods. It can be argued that a shift in the perspective of environmental games usage, or perhaps serious games usage in general, from a strong focus on knowledge provision to more innovative applications is warranted. As Bogost (2008, p. 125) notes, games do not primarily teach by having their players read static text and images—they teach and immerse their players by *having them do things in a context dictated by in-game rules*—solving puzzles, fulfilling quests, becoming stronger, visualizing their in-game impacts, and understanding complex correlations between their actions and

consequences. Knowledge and information in this context do not become secondary to the gameplay experience, as some have been shown to be skeptical of (see Section 4.1.4—Game skepticism); they are merely presented and viewed in different formats. One important note in this regard for the future of green games is to elevate their standing from simple knowledge-provision tools to socially constructed, holistic experiences—a microworld or open-ended universe in which a topic is represented by different artifacts that the player can interact with on their own leisure (Egenfeldt-Nielsen, 2006) and through which they can gain a deeper understanding of the topic from their own referential standpoint, context, and life situation. Also, when combined with a debriefing session (see Section 4.2.3—The importance of debriefing), environmental games can become highly effective educational tools (Madani et al., 2017).

4.2.3 The importance of debriefing

Perhaps the most important part of playing environmental games (aside from the quality and thematic relevance of the games themselves) is the *debriefing* session. The field of educational games in general is characterized by a multitude of learning myths, including notions such as “serious games requiring no debriefing” (Crookall, 2023), which can ultimately be detrimental to the game’s educational value and continued use. During a debriefing, participants are normally asked to reflect upon their experiences with the game, how it made them think and feel during the action, whether they learned anything new or reinforced their existing knowledge somehow, as well as core aspects of the more experiential and phenomenological aspects of the gameplay session (Lederman, 1992). It also represents an arena through which an instructor can pose challenging and thought-provoking questions regarding the game experience, address existing and missing parallels between the game and the real world, and to justify or discuss the inclusion of fantastical rather than realistic elements for game enjoyment purposes. As such, it is therefore an important component in bridging the *simulation gap*—a discrepancy between the actions performed by a player in a serious game compared to a real-life setting (Bogost, 2010, p. 43)—by encouraging, stimulating, and enabling pro-environmental behavior to be conducted outside the game itself. One core misconception about debriefing, however, is that it is exclusively meant to take place *after* the game has been played—or, as one article headlines it, “the real learning begins when the game *stops*” (Tipton et al., 2016). It can be argued that some aspects of debriefing can begin *during* gameplay through casual observation of- and interaction with the players—focusing on gestures or the strategies the players implement in-game for example (Crookall, 2023). In so doing, educators and researchers can perceive and make note of behavioral and affective patterns that would otherwise be inaccessible in a post-game debriefing. Debriefing from educational gameplay today is often remarkably shallow and only covers the pure basics of a gaming experience, thus leaving the players with only the experiential aspects of the game and possibly not seeing the extended educational value of what they have played (Tipton et al., 2016). When done correctly, debriefing can be used to ask questions or provide feedback throughout the gaming session before culminating in a reflective process once the gameplay session ends. Using a more inductive, bottom-up approach to questioning, debriefing can

also encourage the players to openly talk about their gameplay experience to catch unknown or unpredicted aspects of what the game is capable of teaching (e.g., Fjællingsdal and Klöckner, 2019, 2020). Additionally, although debriefing traditionally occurs face-to-face once the gameplay session is concluded, online instant messaging tools such as Discord or Google Forms can both (1) enable easier and more direct communication during the gameplay session, as well as (2) provide the players with the opportunity to participate in individual- or group-based online interviews about their experiences in the game (Crookall, 2023).

4.3 Upscaling environmental game usage

Games have been shown to be able to teach and inspire us about various themes and subjects (Boncu et al., 2022; Janakiraman et al., 2021a,b), but it can be argued that their true potential in encouraging sustainable behavior through a wider application than pilot studies remains untapped. In the previous part of this paper, a set of important factors to upscaling environmental games has been presented. These factors are also of utmost importance to utilizing the educational potential of these types of games, but they are often given little attention in contemporary research. As such, they form a potential scaffolding for the expansion and upscaling of pilot-level gaming studies. They furthermore address some of the most common barriers and hurdles toward implementing environmental games as educational tools. Currently, there appears to exist a hesitation to use games extensively to teach about the climate and the environment. Yet, despite this, there is an outcry for new and innovative means of engaging with new learners and investigating alternative arenas through which the complexity of the ongoing social crises can be explored (e.g., Illingworth, 2020; Redfern et al., 2016). Breaking down these barriers and skepticism is crucial to ensure the increased uptake of games in environmental education, and the previous sections of this paper are intended to help achieve this goal.

5 Conclusion

The purpose of this paper has been to provide a basic set of guidelines surrounding the use of environmental games across various fields of climate education, and to avoid common pitfalls and barriers that could ultimately prevent their upscaling from small-scale pilot studies. To this end, a conceptual analysis of the environmental gaming genre was conducted based on a combination of a literature search and an exploration of popular gaming aggregates. The analysis has revealed that despite the

increasing numbers of environmental games on the market—and the frequency of research into their effectiveness—there still exist significant barriers to their use and upscaling potential that this paper will hopefully help ameliorate, and although the list is likely not entirely exhaustive it will still be a helpful tool for those who wish to use environmental games in their educational activities. It should also be noted that this paper does not suggest replacing conventional learning methods with environmental games; rather, it is suggested to consider that these educational tools are complementary. Lastly, future empirical evaluation and possible expansion of the guidelines described in this paper is encouraged.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements.

Author contributions

KF: Writing – original draft.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Abt, C. C. (1970). *Serious Games*. Lanham, MD: University Press of America.
- Arztmann, M., Hornstra, L., Jeuring, J., and Kester, L. (2023). Effects of games in STEM education: a meta-analysis on the moderating role of student background characteristics. *Stud. Sci. Educ.* 59, 109–145. doi: 10.1080/03057267.2022.2057732
- Baba, N., Uchida, H., and Sawaragi, Y. (1984). A gaming approach to the acid rain problem. *Simul. Games* 15, 304–314. doi: 10.1177/0037550884153003

- Blake, K., Arbieu, U., Tickell, S. C. Y., Kubo, T., Lai, S., Mameno, K., et al. (2024). *How commercial video games could engage players with biodiversity conservation: a systematic map protocol*. SocArXiv. doi: 10.31235/osf.io/gshdp
- BoardGameGeek.com (2024). *Weight*. Available at: <https://boardgamegeek.com/wiki/page/Weight> (accessed January 6, 2025).
- Bogost, I. (2008). "The rhetoric of video games," in *The Ecology of Games: Connecting Youth, Games, and Learning*, ed. K. Salen (Cambridge, MA: The MIT Press).
- Bogost, I. (2010). *Persuasive Games. The Expressive Power of Videogames*. Cambridge, MA: MIT Press.
- Boncu, S., Candel, O. S., and Popa, N. L. (2022). Gameful green: a systematic review on the use of serious computer games and gamified mobile apps to foster pro-environmental information, attitudes and behaviors. *Sustainability* 2022:14. doi: 10.3390/su141610400
- Capcom (2007). *Okami [Video Game]*. Los Angeles, CA: Clover Studio.
- Crapuchettes, D. (2016). *Evolution: Climate [Board Game]*. Bethesda: North Star Games 2016.
- Crawford, C. (1990). *Balance of the Planet [Video Game]*. Chris Crawford.
- Crookall, D. (2023). "Debriefing. A practical guide," in *Simulation for Participatory Education*, eds. M. L. Angelini, and R. Muñoz (Cham: Springer).
- Crowley, E. J., Silk, M. J., and Crowley, S. L. (2021). The educational value of virtual ecologies in Red Dead Redemption 2. *People Nat.* 3, 1229–1243. doi: 10.1002/pan3.10242
- Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience*. New York City: Harper Perennial.
- Dawes, R. M. (1980). Social dilemmas. *Annu. Rev. Psychol.* 31, 169–193. doi: 10.1146/annurev.ps.31.020180.001125
- Egenfeldt-Nielsen, S. (2006). Overview of research on the educational use of video games. *Nordic J. Digital Liter.* 1, 184–214. doi: 10.18261/ISSN1891-943X-2006-03-03
- Eisenack, K., and Petschel-Held, G. (2004). *Keep Cool [Board Game]*. Bavaria: Spieltrieb.
- ESA (2015). *2015 Annual Report. A Year of Innovation and Achievement*. Available at: <https://esamultimedia.esa.int/multimedia/publications/Annual-Report-2015/AR-2015.pdf>
- ESA (2023). *2023 Essential Facts About the U.S. Video Game Industry*. Available at: <https://www.theesa.com/2023-essential-facts/> (accessed January 6, 2025).
- ESRB (2024). *Ratings Guide*. Available at: <https://www.esrb.org/ratings-guide/> (accessed January 6, 2025).
- Feinstein, A. H., and Cannon, H. M. (2002). Constructs of simulation evaluation. *Simul. Gaming* 33, 425–440. doi: 10.1177/1046878102238606
- Fernández Galeote, D., Rajanen, M., Rajanen, D., Legaki, N.-Z., Langley, D. J., and Hamari, J. (2021). Gamification for climate change engagement: review of corpus and future agenda. *Environm. Res. Lett.* 16:063004. doi: 10.1088/1748-9326/abec05
- Fjællingsdal, K. S. (2021). *The Green Gaming Project. The Role of Games in Promoting Environmental Literacy* (PhD Thesis). Trondheim: NTNU Open. Available at: <https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/2753671> (accessed January 6, 2025).
- Fjællingsdal, K. S., and Klöckner, C. A. (2017). ENED-GEM: a conceptual framework model for psychological enjoyment factors and learning mechanisms in educational games about the environment. *Front. Psychol.* 8:1085. doi: 10.3389/fpsyg.2017.01085
- Fjællingsdal, K. S., and Klöckner, C. A. (2019). Gaming green: the educational potential of eco – a digital simulated ecosystem. *Front. Psychol.* 10, 1–13. doi: 10.3389/fpsyg.2019.02846
- Fjællingsdal, K. S., and Klöckner, C. A. (2020). Green across the board: board games as tools for dialogue and simplified environmental communication. *Simul. Gaming* 51, 632–652. doi: 10.1177/1046878120925133
- Flood, S., Cradock-Henry, N. A., Blackett, P., and Edwards, P. (2018). Adaptive and interactive climate futures: systematic review of 'serious games' for engagement and decision-making. *Environm. Res. Lett.* 13:063005. doi: 10.1088/1748-9326/aac1c6
- Galarneau, L. (2005). "Authentic learning experiences through play: games, simulations and the construction of knowledge," in *Proceedings of DiGRA 2005 Conference: Changing Views – Worlds in Play*.
- Gaudelli, W., and Taylor, A. (2011). Modding the global classroom? Serious video games and teacher reflection. *Contemp. Issues Technol. Teach. Educ.* 11, 70–91.
- Gee, J. P. (2005). Learning by Design: good video games as learning machines. *E-Learning* 2, 5–16. doi: 10.2304/elea.2005.2.1.5
- Gifford, R. (2011). The dragons of inaction. Psychological barriers that limit climate change mitigation and adaptation. *Am. Psychol.* 66, 290–302. doi: 10.1037/a0023566
- Girard, C., Ecalte, J., and Magnan, A. (2012). Serious games as new educational tools: how effective are they? A meta-analysis of recent studies. *J. Comp. Assist. Learn.* 29, 207–219. doi: 10.1111/j.1365-2729.2012.00489.x
- Gunter, G. A., Kenny, R. F., and Vick, E. H. (2007). Taking educational games seriously: using the RETAIN model to design endogenous fantasy into standalone educational games. *Educ. Technol. Res. Dev.* 56, 511–537. doi: 10.1007/s11423-007-9073-2
- Hallinger, P., Wang, R., Chatpinyakoo, C., Nguyen, V.-T., and Nguyen, U.-P. (2020). A bibliometric review of research on simulations and serious games used in educating for sustainability, 1997–2019. *J. Clean. Prod.* 256, 1–15. doi: 10.1016/j.jclepro.2020.120358
- Hardin, G. (1968). The tragedy of the commons. *Science* 162, 1243–1248. doi: 10.1126/science.162.3859.1243
- Heron, M., and Crabb, M. (2023). Paddling in the shallows: game domain knowledge within non-game disciplines (a manifesto for doing better research with games). *SSRN Electronic J.* doi: 10.2139/ssrn.4650415
- Ho, N., and Sommers, M. (2013). Anhedonia: a concept analysis. *Arch. Psychiatr. Nurs.* 27, 121–129. doi: 10.1016/j.apnu.2013.02.001
- Illingworth, S. (2020). Creative communication – using poetry and games to generate dialogue between scientists and nonscientists. *FEBS Lett.* 594, 2333–2338. doi: 10.1002/1873-3468.13891
- Illingworth, S., and Wake, P. (2019). Developing science tabletop games: Catan and global warming. *J. Sci. Commun.* 18, 1–21. doi: 10.22323/2.18040204
- IPBES (2019). Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services. Available at: <https://zenodo.org/records/3553579> (accessed January 6, 2025).
- IPCC (2023). "Summary for policymakers," in *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Available at: https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf (accessed January 6, 2025).
- Janakiraman, S., Watson, S. L., and Watson, W. R. (2021b). Exploring the effectiveness of digital games in producing pro-environmental behaviors when played collaboratively and individually: a mixed methods study in India. *TechTrends* 65, 331–347. doi: 10.1007/s11528-020-00571-8
- Janakiraman, S., Watson, S. L., Watson, W. R., and Newby, T. (2021a). Effectiveness of digital games in producing environmentally friendly attitudes and behaviors: a mixed methods study. *Comput. Educ.* 160:104043. doi: 10.1016/j.compedu.2020.104043
- Jennett, C., Cox, A. L., Cairns, P., Dhope, S., Epps, A., Tijs, T., et al. (2008). Measuring and defining the experience of immersion in games. *Int. J. Human Comp. Stud.* 66, 641–661. doi: 10.1016/j.ijhcs.2008.04.004
- Klöckner, C. A. (2015). *The Psychology of Pro-Environmental Communication*. London: Palgrave-Macmillan.
- Klopfer, E., Osterweil, S., and Salen, K. (2009). *Moving Learning Games Forward. Obstacles, Opportunities & Openness*. Cambridge, MA: The Education Arcade.
- Koehler, M. J., Arnold, B., Greenhalgh, S. P., and Boltz, L. O. (2017). A taxonomy approach to studying how gamers review games. *Simul. Gaming* 48, 363–380. doi: 10.1177/1046878117703680
- Landers, R. N., Tondello, G. F., Kappen, D. L., Collmus, A. B., Mekler, E. D., and Nacke, L. E. (2019). Defining gameful experience as a psychological state caused by gameplay: replacing the term 'Gamefulness' with three distinct constructs. *Int. J. Hum. Comput. Stud.* 127, 81–94. doi: 10.1016/j.ijhcs.2018.08.003
- Lederman, L. C. (1992). Debriefing: toward a systematic assessment of theory and practice. *Simul. Gaming* 23, 145–160. doi: 10.1177/1046878192232003
- Madani, K., Pierce, T. W., and Mirchi, A. (2017). Serious games on environmental management. *Sustain. Cities Soc.* 29, 1–11. doi: 10.1016/j.scs.2016.11.007
- McBean, G. A., and Hengeveld, H. G. (2000). Communicating the science of climate change: a mutual challenge for scientists and educators. *Can. J. Environm. Educ.* 5, 9–23.
- McGonigal, J. (2011). *Reality Is Broken: Why Games Make Us Better and How They Can Change the World*. New York, NY: The Penguin Press.
- McNamara, D., Jackson, G., and Graesser, A. (2009). "Intelligent tutoring and games (iTaG)," in *Proceedings of the 14th Annual Conference on Artificial Intelligence in Education*, eds. H. Lane, A. Ogan, and V. Shute (Brighton, UK: AIED).
- Meadows, D. (1986). *Fish Banks [Board Game]*. Dennis Meadows.
- Möring, S., and Schneider, B. (2024). "Climate–game–worlds: a media-aesthetic look at the depiction and function of climate in computer games," in *Ecogames. Playful Perspectives on the Climate Crisis*, eds. L. op de Beke, J. Raessens, S. Werning, and G. Farca (Amsterdam University Press).
- Moser, S. C. (2016). Reflections on climate change communication research and practice in the second decade of the 21st century: what more is there to say? *WIREs Clim. Change* 7, 345–369. doi: 10.1002/wcc.403
- Norman, G., Dore, K., and Grierson, L. (2012). The minimal relationship between simulation fidelity and transfer of learning. *Med. Educ.* 46, 636–647. doi: 10.1111/j.1365-2923.2012.04243.x

- Oddworld Inhabitants (2005). *Oddworld: Stranger's Wrath [Video Game]*. Redwood City, CA: EA Games.
- Ouariachi, T., Olvera-Lobo, M. D., and Gutiérrez-Perez, J. (2018). "Serious games and sustainability," in *Encyclopedia of Sustainability and Higher Education*, ed. W. L. Filho (Cham: Springer).
- Powers, R. B. (1987). Bringing the commons into a large university classroom. *Simul. Gaming* 18, 443–457. doi: 10.1177/0037550087184001
- Rajanen, D., and Rajanen, M. (2019). "Climate change gamification: a literature review," in *Proceedings of the 3rd International GamiFIN Conference* (Finland: RWTH Aachen University).
- Reckien, D., and Eisenack, K. (2013). Climate change gaming on board and screen: a review. *Simul. Gaming* 44, 253–271. doi: 10.1177/1046878113480867
- Red Redemption (2011). *Fate of the World [PC Game]*. San Diego, CA: Red Redemption.
- Redfern, J., Illingworth, S., and Verran, J. (2016). What does the UK public want from academic science communication? *F1000Res.* 5:1261. doi: 10.12688/f1000research.8815.1
- Rice, J. W. (2006). "New media resistance: barriers to implementation of computer video games in the classroom," in *Paper presented at American Educational Research Association* (San Francisco, CA: 2006 Annual Meeting San Francisco, CA).
- Robinson, J., and Ausubel, J. H. (1983). A game framework for scenario generation for the CO₂ issue. *Simul. Gaming* 14, 317–344. doi: 10.1177/104687818301400306
- Ryan, R. M., Rigby, C. S., and Przybylski, A. (2006). The motivational pull of video games: a self-determination theory approach. *Motiv. Emot.* 30, 344–360. doi: 10.1007/s11031-006-9051-8
- Schell, J. (2010). *The Art of Game Design: A Book of Lenses*. Amsterdam: Elsevier.
- Skaug, J. H., Husøy, A., Staaby, T., and Nøsen, O. (2020). Spillpedagogikk. Dataspill i undervisningen [Gaming Pedagogy. Computer Games in Teaching]. Delhi: Fagbokforlaget.
- Somerville, R. C. J., and Hassol, S. J. (2011). Communicating the science of climate change. *Phys. Today* 64, 48–53. doi: 10.1063/PT.3.1296
- Spanellis, A., Harviainen, J. T., Fernández Galeote, D., and Thibault, M. (2024). Editorial: Gamification for sustainable development. *Simulat. Gaming* 55, 1–5. doi: 10.1177/10468781241249324
- Square (1997). *Final Fantasy 7 [Video Game]*. San Mateo, CA: Sony Computer Entertainment.
- Strange Loop Games (2020). *Eco [PC Game]*. Seattle, WA: Strange Loop Games.
- Sturgis, P., and Allum, N. (2004). Science in society: re-evaluating the deficit model of public attitudes. *Public Understand. Sci.* 13, 55–74. doi: 10.1177/0963662504042690
- Talan, T., Yunus, D., and Veli, B. (2020). Efficiency of digital and nondigital educational games: a comparative meta-analysis and a meta-thematic analysis. *J. Res. Technol. Educ.* 52, 474–514. doi: 10.1080/15391523.2020.1743798
- Theodosiou, S., and Karasavvidis, I. (2015). Serious games design: a mapping of the problems novice game designers experience in designing games. *J. E-learn. Knowl. Soc.* 11, 133–148. doi: 10.20368/1971-8829/1071
- Tipton, E., Leigh, E., Kriz, W., and Crookall, D. (2016). "Debriefing: the real learning begins when the game stops," in *Simulation and Gaming in the Network Society*, eds. T. Kaneda, Y. Toyoda, and P. Rizzi (Cham: Springer).
- van der Linden, S., Maibach, E., and Leiserowitz, A. (2015). Improving public engagement with climate change: five "best practice" insights from psychological science. *Persp. Psychol. Sci.* 10, 758–763. doi: 10.1177/1745691615598516
- Wang, H., and Coren, E. (2024). "Storytelling as a catalyst for climate change communication and empowerment," in *Storytelling to Accelerate Climate Solutions*, eds. H. Wang and E. Coren (Cham: Springer).
- Wright, W. (1990). *SimEarth [Video Game]*. New York, NY: Maxis.
- Wu, J. S., and Lee, J. J. (2015). Climate change games as tools for education and engagement. *Nat. Clim. Chang.* 5, 413–418. doi: 10.1038/nclimate2566



OPEN ACCESS

EDITED BY

Giuseppe Carrus,
Roma Tre University, Italy

REVIEWED BY

Hilmar Brohmer,
University of Graz, Austria
Nida Hussain,
Zhengzhou University, China

*CORRESPONDENCE

Laura Höpfl
✉ laura.hoepfl@ife.uni-stuttgart.de

RECEIVED 31 July 2024

ACCEPTED 18 December 2024

PUBLISHED 28 January 2025

CITATION

Höpfl L, Đula I, Kiss F, Walter R and
Wirzberger M (2025) Efficacy of personalized
feedback in encouraging sustainable washing
behavior: evidence from a pilot study in
Germany. *Front. Psychol.* 15:1473953.
doi: 10.3389/fpsyg.2024.1473953

COPYRIGHT

© 2025 Höpfl, Đula, Kiss, Walter and
Wirzberger. This is an open-access article
distributed under the terms of the [Creative
Commons Attribution License \(CC BY\)](#). The
use, distribution or reproduction in other
forums is permitted, provided the original
author(s) and the copyright owner(s) are
credited and that the original publication in
this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Efficacy of personalized feedback in encouraging sustainable washing behavior: evidence from a pilot study in Germany

Laura Höpfl^{1,2,3*}, Ivan Đula^{1,3,4}, Francisco Kiss², Rebecca Walter²
and Maria Wirzberger^{1,3,4}

¹University of Stuttgart, Teaching and Learning with Intelligent Systems, Stuttgart, Germany, ²Robert Bosch GmbH, Stuttgart, Germany, ³University of Stuttgart, Cluster of Excellence EXC 2075 'Data-Integrated Simulation Science', Stuttgart, Germany, ⁴University of Stuttgart, Interchange Forum for Reflecting on Intelligent Systems, Stuttgart, Germany

Introduction: Reducing household energy consumption through behavioral changes is a key strategy in addressing the emissions driving the climate crisis. Behavioral changes in affluent households toward more sustainable practices can have a significant positive impact. Prior research highlighted the role of individual values and motivational factors in shaping sustainable clusters. A more personalized approach toward encouraging the resulting clusters of people to adopt more sustainable strategies seems promising. Such an approach could incorporate aligned feedback, which has been proven to be a powerful mechanism throughout learning processes.

Method: Over 9 weeks, a pilot study with 50 participants investigated the impact of different types of feedback on washing behavior. The within-subjects design included (1) a baseline condition, (2) feedback on energy consumption (kWh), and (3) feedback on monetary costs per cycle (EUR). Data collection encompassed pre- and post-condition surveys, a final comprehensive survey, and a diary-formatted table. The primary objective was to evaluate the potential for individualization. Asynchronous structured interviews were conducted at the end to explore participants' perceptions and washing behaviors.

Results: While we found effects for the feedback manipulation, we found no differences between user clusters in individual washing behaviors. Furthermore, participants qualitatively reported habitual changes, feeling more knowledgeable about the monetary impacts of specific washing programs and temperatures, and wished for a more accessible preset time function. Most participants expressed willingness to switch to a dynamic energy price if it translated to significant cost savings.

Discussion: Our findings may support the notion that individualized behavior change strategies are promising. In general, these strategies should be easily applicable, cost-effective, and promote habits to be exerted regularly. Arising methodological limitations suggest further research in this domain. From an applied perspective, our research provides valuable insights for designing products, services, and regulations by governments and companies, empowering them to develop more effective strategies for reducing energy consumption.

KEYWORDS

behavioral science interventions, barriers in the real world, individualized feedback, personalized interventions, energy consumption reduction

1 Introduction

Reducing greenhouse gas (GHG) emissions is essential to decelerate climate change and mitigate its unpredictable negative consequences (Lee, 2008; Grubb et al., 2022). GHG emissions are measurable and can be influenced by human activities. Examples of reduction strategies include utilizing low-carbon energy sources and carriers, adopting energy-efficient appliances and systems, and promoting behavioral changes to decrease energy demand (Creutzig et al., 2022). Since private households are a significant source of GHG emissions, behavioral changes can substantially reduce those emissions (Dhakal et al., 2022). In general, GHG emissions of high-income households are typically above average due to larger homes and more frequent air travel enabled by greater resource access. On a global scale, households within the highest 10% income bracket are responsible for ~36–45% of the total GHG emissions (Shukla et al., 2022).

Thereby, heating is an essential component that significantly contributes to household emissions across many countries. While in regions such as Brazil or India, cold washes are the norm (Spencer et al., 2015), utilizing less energy, in most of Western Europe, washing clothes and textiles with heated water is common (Pakula and Stamminger, 2010). Consequently, the share of electricity consumption for laundry in Europe represents between 3.8 and 9.2%, thereby contributing to household emissions on a daily basis. Influencing consumer preferences and demand is essential for driving change among high-income households. Therefore, we investigate whether technical design features in consumer products can support behavioral adaptation toward more sustainable energy consumption.

Consequently, addressing consumer preferences and demand is critical to achieving a change for high-income households. Entrepreneurs and companies can shape consumer preferences by designing their products, systems, and services with reduced energy demand and fostering a more sustainable usage. For companies, a shift toward more sustainable design is both an opportunity and a potential source of conflict. Opportunities lay, for example, in lowering the dependence on environmentally critical resources (Bansal, 2005; Lubin and Esty, 2010), which could be pivotal for product manufacturing. Additionally, a more sustainable product design can reduce resource consumption in both production and subsequent consumption phases, for example, through up-scaling interventions targeting behavior change. Furthermore, companies can leverage the growing demand for sustainable products and services by offering environmentally friendly and socially responsible products. This trend presents an opportunity for companies to develop competitive advantages that align with the values and preferences of environmentally conscious consumers, potentially increasing the market share in this segment.

Existing evidence indicates various approaches that can promote sustainable behavior through design. Concretely, product designers could leverage the effects of social influence (Albarracín et al., 2024), habit formation (Albarracín et al., 2024), feedback (Hummel and Maedche, 2019), emotional attachment toward a product, tangibility, ease of use (White et al., 2019), boosting (Hertwig, 2017), or nudging (Hummel and Maedche, 2019). Boosting involves empowering people to engage in well-informed

independent decision-making (Hertwig, 2017), whereas nudging seeks to influence people's conscious and unconscious decisions by altering the choice architecture (Balmford et al., 2021). Thereby, a nudge is defined as an external factor that can influence people's behavior (Thaler and Sunstein, 2008). These subtle impulses aim to guide individuals toward desired behaviors. For instance, positioning healthy food options at eye level in a cafeteria can encourage consumers to make healthier choices (Vandenbroele et al., 2020).

Comprehensive comparative research has shown significant effects related to behavior change for several interventions. These interventions include providing feedback to the user, setting a default for the task to encourage preferred behavior, simplifying the task to reduce effort, and adding a comparison through social reference (Hummel and Maedche, 2019). Looking into established mechanisms of behavioral change in learning research, we see that particularly feedback is a powerful tool that has been employed across various formal and informal learning and training settings (Hattie and Timperley, 2007; Shute, 2008). Feedback can convey valuable insights for users, including achievements, consequences, and associated implications, such as financial and environmental implications.

To ensure that feedback is actionable, Hysong et al. (2006) consider timeliness, personification, customizability, and non-punitiveness as crucial factors. Thereby, non-punitiveness involves avoiding a punishing feedback tone. Individualization refers to feedback on personal performance rather than aggregated data. Timeliness concerns the frequency of feedback, while customizability addresses presenting performance data in a personally meaningful way (Hysong et al., 2006). Considering its demonstrated effectiveness as tool to facilitate learning processes in numerous studies, feedback holds promise for facilitating the adoption and enhancement of sustainable behaviors among individuals. Even though behavioral interventions, such as feedback, are effective, the challenge remains that they often exhibit modesty due to temporary, context-dependence (Balmford et al., 2021). Hence, behavior change could be influenced by addressing individual differences with personification such as monetary incentivization through feedback. Individualized products and services might have great potential since they can cater to users' diverse needs, motivations, and values (Koren et al., 2015).

Previous research indicated that incorporating personal attitudes, values, and motivational factors could be an effective strategy for promoting sustainable thinking and behavior (Steg and de Groot, 2019). More precisely, developing personalized approaches for encouragement might be promising (Höpfel et al., 2024; Briem et al., 2019). Working toward this goal, previous research builds on dimensions such as belief in climate change, collaboration, or skepticism concerning sustainability (Höpfel et al., 2024). Based on a sample of 351 participants, the proposed approach identified five intention-based sustainability clusters via data-driven clustering. Individuals assigned to the Socially sustainable cluster are characterized by peer group-motivated pro-environmental behavior, while those assigned to the Responsible savers cluster emphasize sustainable products motivated by environmental concerns. In contrast, individuals assigned to the Unconcerned spenders cluster display a greater need

for immediate gratification, and those assigned to the Comfort-oriented cluster have a low awareness of sustainable consumption. Lastly, individuals assigned to the Skeptical consumer cluster exhibit the highest barrier to exerting a more sustainable lifestyle. Embedding such distinctive perspectives and related behavioral implications in sustainability research enables a more comprehensive understanding of individuals' willingness and motivation to change.

Consequently, building on the introduced sustainability clusters, we further explore the potential of personalized behavioral interventions to promote reduced GHG emissions and encourage a less carbon-intense lifestyle. Utilizing a mixed-methods approach that combines behavioral measurements and interviews within a field study, we investigate strategies to promote behavioral changes in private households, focusing on washing practices as a case example. Sustainable washing behavior can be characterized by variables such as washing at lower temperatures (Hauthal, 2012), longer duration (Alborzi et al., 2017), and lower counts of wash loads (Pakula and Stamminger, 2010). Furthermore, longer washing cycles correlate with the lower temperatures (Alborzi et al., 2017).

We consider feedback a fundamental strategy for promoting behavioral change due to its evidence-based effects, informative value in design, and flexibility in adjusting various variables. Consequently, we analyze different feedback conditions and their impact on behavior in a field study conducted in German households. More precisely, these include (i) information on kilowatt-hours spending, (ii) monetary investment, and (iii) a baseline without further information. Based on evidence from previous research (Höpfl et al., 2024), we investigate three core hypotheses¹: First, we propose that participants will exert different washing behaviors if they receive the outlined different types of feedback (H1). Additionally, participants assigned to different sustainability clusters should exert different washing behaviors (H2). Lastly, we assume that participants assigned to different sustainability clusters will respond with different washing behaviors to feedback conveyed in euro [EUR, €] or kilowatt-hours [kWh] (H3). We assume the monetary factor to be the stronger determinant (Vohs et al., 2006) compared to energy consumption.

Taken together, while we found effects for the feedback manipulation, we found no differences between user clusters in individual washing behaviors. Furthermore, participants qualitatively reported habitual changes, feeling more knowledgeable about the monetary impacts of specific washing programs and temperatures, and wished for an adaption of specific washing modes, such as a more accessible preset time function. Most participants expressed willingness to switch to a dynamic energy price if it translated to significant cost savings. Our findings support the notion that individualized behavior change strategies might be promising. In general, these strategies should be easy, cost-effective, and promote habits to be exerted regularly. Arising methodological limitations suggest further research in this domain. From an applied perspective, our research

provides valuable insights for designing products, services, and regulations by governments and companies, empowering them to develop more effective strategies for reducing household energy consumption.

2 Methods

In a pilot study, we investigated whether there are variations in behavioral reactions to modified feedback among different sustainability clusters. In addition to a 9-week quantitative behavioral field experiment phase, we conducted structured asynchronous interviews ($n = 39$) to receive further information about the perception of the different feedback types. The study plan for data collection and analysis was approved by the Committee for Responsibility in Research of Stuttgart (approval number: Az. 23-061) and pre-registered at OSF.² We obtained informed consent from all participants and followed the General Data Protection Regulation (GDPR; EU, 2016). Furthermore, we closely followed relevant guidelines and regulations outlined in Standard 8 of the Ethical Principles and Code of Conduct for Psychologists (American Psychological Association, 2010).

2.1 Participants

Most households in Germany fall within the top 10% of the highest income bracket worldwide, making the sample suitable for our purposes. To accurately represent the 80 million German inhabitants responsible of washing, we utilized the services of TestingTime (2023), a specialized agency known for selecting representative samples. Thereby, an initial set of 51 participants was selected (see text footnote 2). As part of the screening process, participants were asked to identify the household items they personally use on a regular basis. Those who did not report regular use of a washing machine were excluded from the study. After data cleaning and excluding a participant due to missing data, our final sample size consisted of 50 participants aged between 24 and 66 ($M_{age} = 42.4$ years, $SD_{age} = 8.73$) with a majority of 66% being female. Most participants resided in either 3-person households (43.14%) or 4-person households (43.14%) and reported having one child (52.94%) or two children (41.18%) residing in the same household. Regarding monthly household income, most participants fell between 3,600 and 5,000 € (43.14%) or exceeded 5,000 € (39.23%). Participants received a monetary compensation of 95 € for completion of the study.

2.2 Design

We implemented a within-subjects design, wherein each participant underwent three feedback conditions for 3 weeks each,

¹ Our reported set of hypotheses differs from the preregistered hypothesis formulations to provide a more concise and coherent alignment with the chosen and preregistered research design.

² The preregistration, a comprehensive list of the included items, the qualitative questions, and additional information about recruitment procedures can be found in: <https://osf.io/j3ny7>.

resulting in different information displayed on an electricity meter. The study explored the impact of sustainability clusters (Socially sustainable cluster vs. Responsible savers cluster vs. Unconcerned spenders cluster vs. Comfort-oriented cluster vs. Skeptical consumer cluster) and feedback (baseline vs. energy consumption in kWh vs. monetary investment in EUR) as independent variables. The dependent variables in this study encompass various aspects of washing behavior, such as temperature, count of wash loads, and cycle duration in minutes. The three conditions were presented sequentially in a fixed order, as we assumed that the monetary investment would have a greater impact and that the effects of energy consumption would disappear. The qualitative portion of the study involved conducting structured interviews. A specific interview guide was used to maintain consistency across interviews, with open-ended questions focusing on feedback conditions, changes in washing behavior, and the delay function of washing machines. We selected an asynchronous format to ensure consistent question delivery, give participants the flexibility to respond at their convenience, and allow for more thoughtful and detailed answers.

2.3 Materials

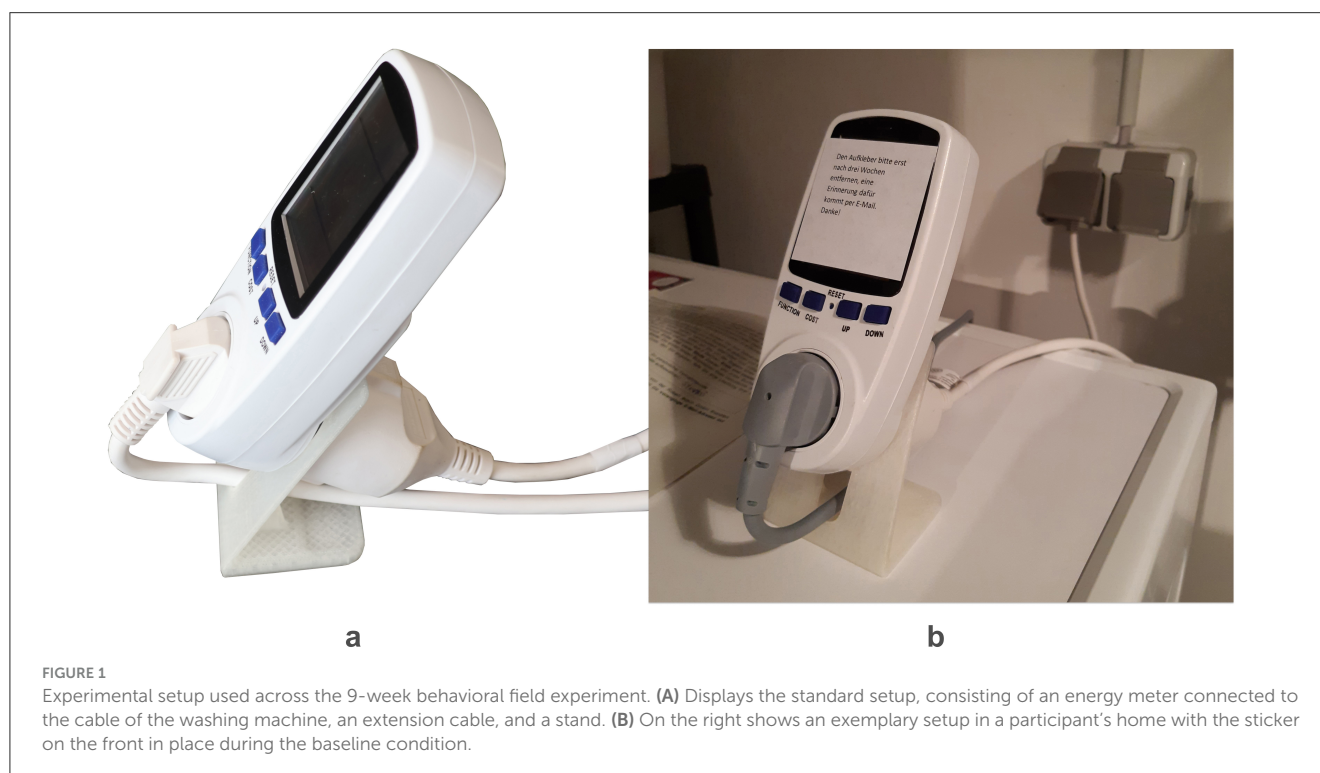
Visual feedback was provided on electricity meters of the brand X4-LIFE, which were chosen due to their versatility. All materials were sent via mail to each participant's home, including the operating instructions, an extension cable, a stand for the appliance, instructions for assembly, data protection information, participant information, and a table for documenting the washing cycles (see text footnote 2). The experimental arrangement is

depicted in Figure 1, alongside the setup used by an individual participant. In Figure 2, the three different conditions are displayed. The study included four surveys and utilized the online survey tool SoSci Survey (Leiner, 2019) for data collection. Additionally, a self-created diary-formatted table was utilized to record washing behavior.

Assessing participants' affiliation with sustainability clusters involved a previously developed screening instrument derived from Höpfel et al. (2024). The instrument builds on established trust scales regarding sustainable labels (Voon et al., 2011), skepticism toward pro-environmental advertising (Mohr et al., 1998; Obermiller and Spangenberg, 1998), economic benefits in terms of pricing, social status, and social norms (Lee, 2008; Suki and Suki, 2015), believe in human-made climate change, and care for sustainability (see text footnote 2).

2.4 Procedure

The data collection process included an initial survey, a survey administered after each condition, a concluding survey, a diary-formatted table for ongoing entries, and a reflective interview. The experimental procedure is depicted in Figure 3. The instructions and survey links were sent to the participants via email. Data collection was conducted utilizing the SoSci Survey platform (Leiner, 2019). Participants completed the first survey after receiving the required hardware via mail and installing the device at their washing machines. Additionally, they provided demographic data, the cost of 1 kWh in their respective households, which laundry cycles they used, and filled in the screening for assignment to a specific sustainability cluster. Over 9 weeks,



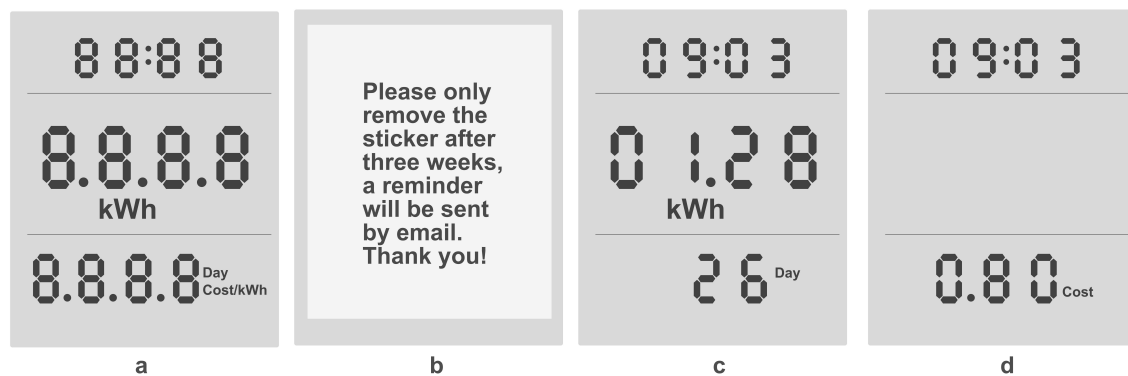


FIGURE 2

Visual setup of conditions. Setup of (A) all displayable options of the energy meter, (B) baseline condition (sticker in place), (C) condition 2 (time, kWh, day), (D) condition 3 (time, cost per wash cycle).

participants meticulously documented their washing behavior in a printed table designed to be affixed to the washing machine. Setup changes related to different conditions were performed upon instruction by removing stickers on the energy meter or changing the setup of the energy meter. In condition (1), the baseline condition, the energy meter was sealed with a sticker, and participants received no further information. Participants annotated the date, time, name of the laundry cycle, temperature, cycle duration in minutes, time preselection (in h), and individual time flexibility for certain wash cycles in the provided table in weeks 1–3. In kWh condition (2), participants removed the sticker and got feedback in the form of kWh per wash cycle. In addition, participants annotated the feedback in the form of kWh in weeks 4–6. In EUR condition (3), participants received feedback in form of EUR, which was calculated as the product of the consumed kWh and the individual energy price per kWh. In addition, participants annotated the EUR per washcycle in weeks 6–9.

After completing the three conditions, the participants received the structured interview questions via email to answer asynchronously. They submitted their responses by sending audio files via email. In the final questionnaire, participants confirmed conscientious and responsible participation and provided information on unusual events during participation, such as extended visits, illness, vacation, or other. Participants needed, on average, $M_{duration} = 35$ min ($SD_{duration} = 10.25$, range: 17–55 min) to fill in all four surveys and conduct the required setup changes.

2.5 Data preparation and scoring

Certain participants were unable to provide the correct participant code consistently, necessitating the establishment of a mapping for these cases. Sustainable washing behavior was measured by cycle count, temperature, and cycle duration in minutes, which were calculated from the washing tables participants provided. We employed a decision tree to assign participants to different sustainability clusters, following the approach reported in Höpfel et al. (2024). We assessed the results

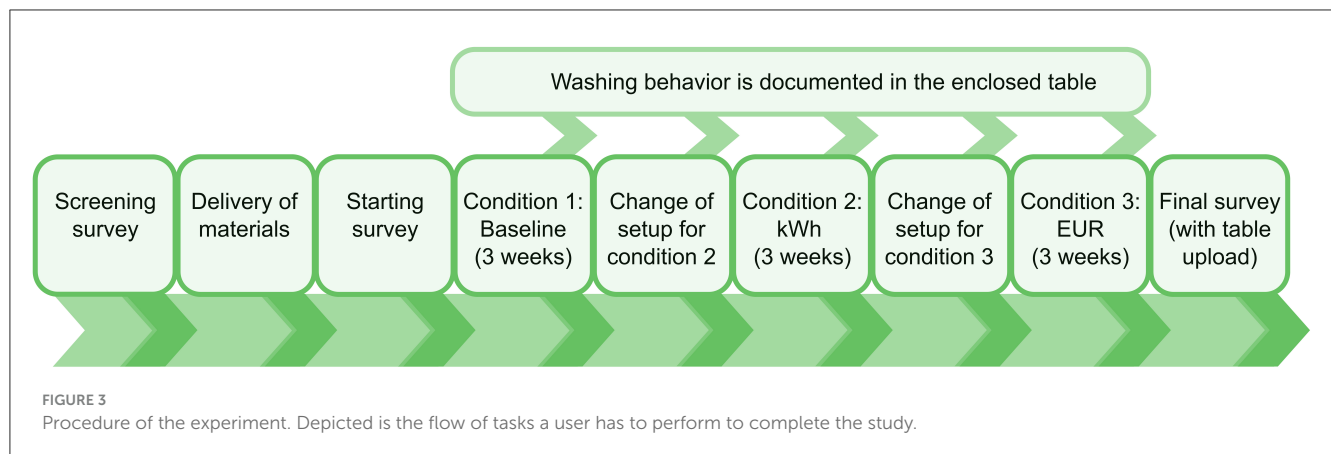
using the silhouette score for cluster evaluation. The procedure resulted in clusters of differing sizes; the Skeptical consumer cluster included nine participants, no participant was clustered according to the Socially sustainable cluster, the Responsible savers cluster included 21 participants, the Unconcerned spenders cluster included two participants, and the Comfort-oriented cluster included 16 participants. The data preparation, scoring, and analysis code was written in Python 3 (van Rossum and Drake, 2009), with Anaconda 3 (Anaconda Inc., 2020), and Jupyter Notebook (Kluyver et al., 2016) as integrated development environment (IDE) as well as Scipy (Virtanen et al., 2020) and Scikit-learn (Pedregosa et al., 2011) as involved libraries. The interviews were transcribed verbatim and analyzed using MAXQDA (MAXQDA, 2021), a software designed to assist in coding.

3 Results

While we found differences in the feedback manipulation, we found no effect between user clusters in individual washing behaviors. Furthermore, participants qualitatively reported habitual changes, feeling more knowledgeable about the monetary impacts of specific washing programs and temperatures, and wished for a more accessible preset time function. Most participants expressed willingness to switch to a dynamic energy price if it translated to significant cost savings.

3.1 Quantitative results

On average, participants washed $M_{cyclecount} = 44.39$ times throughout the experiment ($SD_{cyclecount} = 26.85$, range: 12–157 times), breaking down to 4.93 cycles per week. The average duration was $M_{duration} = 106.13$ min per wash load ($SD_{duration} = 34.78$, range: 14–257 min). The mean temperature over all participants was $M_{temperature} = 41.36^{\circ}\text{C}$ ($SD_{temperature} = 4.60^{\circ}\text{C}$, range: 30–56.35°C). The clustering did not perform well on the current study's data, with a silhouette score of $s = 0.24$. Descriptive characteristics of washing behavior across sustainability clusters are



displayed in Table 1, whereas Table 2 outlines sustainability-related values, motivations, and attitudes means across these clusters.

Linear mixed effect models (LMM) were conducted to test the proposed hypotheses for both temperature and cycle duration. They included feedback manipulations and sustainability clusters as fixed effects and participants as random effects. Due to a deviating aggregation level for cycle count, a repeated measures ANOVA was performed to inspect the effects of feedback and sustainability clusters as proposed in the hypotheses. All obtained effects were adjusted with Benjamini-Hochberg correction (Benjamini and Hochberg, 1995) to avoid type-I-error inflation.

Inspecting the effects of feedback manipulation on the dependent variables of temperature, cycle duration, and cycle count, analyses indicated a significant effect for temperature as displayed in Table 3, with a decrease in temperature by $M = 0.4^\circ\text{C}$ for each condition. By contrast, no significant effect could be observed for cycle duration as outlined in Table 4 and cycle count ($F(2, 126) = 0.21, p = 0.997, \eta_p^2 = 0.01$). Hence, H1 can be partially confirmed in the tested sample.

Examining the impacts of participants' assignment to different sustainability clusters on cycle count, temperature, and cycle duration indicates no significant differences, as presented for temperature in Table 3, for cycle duration in Table 4, and cycle count ($F(3, 126) = 0.86, p = 0.997, \eta_p^2 = 0.02$) as displayed in Table 2 and Figure 4. As a result, H2 could not be confirmed in the tested sample. To investigate if participants assigned to different sustainability clusters respond with different washing behaviors to feedback conveyed in EUR or kWh, we inspected the related interaction effects. Our analyses indicated no statistically significant interaction for temperature Table 3, cycle duration Table 4, or cycle count ($F(6, 126) = 0.1, p = 0.997, \eta_p^2 = 0.00$). Therefore, we could not receive support for H3 in our tested sample.

3.2 Qualitative results

From qualitative analyses of the interview transcripts, displayed in Table 5, we see that most participants wondered about the high energy savings from lower temperatures, their washing amount,

the variability in electricity consumption for the same wash cycle, and the efficiency of the eco-program. According to participants' responses, different types of feedback partially influenced their washing behavior, while some aspects remained unchanged. Due to the low cost of a single wash cycle, some participants reported washing more carefree. Some participants were open to switching to a dynamic electricity price. A few participants experienced ease-of-use issues with the energy meter, while adjusting the electricity meter to their individual energy price was also reported to be a problem for some participants. Regarding technology improvements, many participants suggested changes in the time preselection function and further implementing feedback washing machines as present in the study. Participants expressed demand for an option to select the desired completion time for the washing machine instead of specifying when a washing cycle should start. Participants reported an according change would make it easier to schedule longer wash cycles, such as the eco-program which are harder to integrate in everyday life. Most participants expressed interest in gaining a better understanding of their electricity usage and the energy consumption associated with different wash cycles. Additionally, participants reported adopting new habits, such as using solar energy, the time preset function, setting an alarm clock, and eco-friendly washing cycles more often, leading to a more sustainable approach to washing.

4 Discussion

The increased GHG emissions and the resulting climate change endanger our modern societies, and private household energy consumption significantly contributes to these emissions. We aimed to analyze the effects of different types of feedback on individual washing behavior in a 9-week field experiment. Building on prior evidence we further investigated the impact of sustainability clusters, hinting that more personalized interventions could result in more sustainable behavior. We chose to focus on studying washing behavior because washing machines require limited interactions and can be operated by a single individual for the duration of the experiment, allowing us to measure this individual's behavior. Our quantitative results indicated partial support for our hypothesis within the selected sample. First, we proposed that participants would exert different washing behaviors

TABLE 1 Descriptive statistics for washing behavior across sustainability clusters.

Cluster	Temperature		Cycle length (min)		Cycle count	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Skeptical consumer	43.79	9.84	96.47	50.78	59.86	24.45
Responsible savers	40.66	10.63	101.37	60.67	75.18	44.30
Unconcerned spenders	36.71	4.73	117.5	62.68	39.11	11.35
Comfort-oriented	40.39	14.52	113.03	55.52	51.47	19.95

Skeptical consumer cluster (10 participants), Responsible saver cluster (22 participants), Unconcerned spenders cluster (two participants), and Comfort-oriented cluster (17 participants).

TABLE 2 Dimensions of sustainability-related values and attitudes across clusters.

Sustainability clusters	Social status		Skepticism		Economic benefit		Trust		Care sustainability	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Skeptical consumer	2.65	0.56	2.20	0.39	2.50	0.67	2.93	0.52	1.40	0.52
Responsible savers	3.18	0.81	3.26	0.70	2.98	0.65	4.29	0.36	1.00	0.00
Unconcerned spenders	1.67	0.94	1.83	1.18	2.00	1.42	2.50	2.12	3.50	0.71
Comfort-oriented	2.59	0.59	3.02	0.57	2.44	0.68	3.90	0.28	2.00	0.00

Skeptical consumer cluster (10 participants), Responsible saver cluster (22 participants), Unconcerned spenders cluster (two participants), and Comfort-oriented cluster (17 participants). Following Höpfel et al. (2024).

TABLE 3 Regression table of the model with linear mixed effects for the variable temperature.

	β	<i>SE</i>	<i>z</i>	95% CI		<i>p</i>
				<i>LL</i>	<i>UL</i>	
Feedback	-0.38	0.13	-3.09	-0.65	-0.15	.006
Clusters	-0.67	1.25	-0.54	-3.12	1.78	.593
Feedback: Cluster	-0.05	0.05	-1.01	-0.15	0.05	.311

Number of observations = 2,086, number of subjects = 46, method: REML, Aikake Information Criterion (AIC) = 10,151.01, Bayesian Information Criterion (BIC) = 10,179.22, Log-Likelihood (LL) = -5,070.50, Intraclass Correlation Coefficient (ICC) = 0.96. CI, confidence interval; LL, lower limit; UL, upper limit. Adjustment of *p*-values with Benjamini-Hochberg correction (Benjamini and Hochberg, 1995). Skeptical consumer cluster (10 participants), Responsible saver cluster (22 participants), Unconcerned spenders cluster (two participants), and Comfort-oriented cluster (17 participants).

TABLE 4 Regression table of the model with linear mixed effects for the variable cycle duration.

	β	<i>SE</i>	<i>z</i>	95% CI		<i>p</i>
				<i>LL</i>	<i>UL</i>	
Feedback	3.00	2.324	1.29	-1.55	7.56	0.294
Clusters	6.3	3.931	1.60	-1.41	14.00	0.294
Feedback: Cluster	-0.91	0.88	-1.03	-2.64	0.82	0.304

Number of observations = 2,086, number of subjects = 46, method: REML, Aikake Information Criterion (AIC) = 22,048.23, Bayesian Information Criterion (BIC) = 22,076.44, Log-Likelihood (LL) = -111019.11, Intraclass Correlation Coefficient (ICC) = 0.34. CI, confidence interval; LL, lower limit; UL, upper limit. Adjustment of *p*-values with Benjamini-Hochberg correction (Benjamini and Hochberg, 1995). Skeptical consumer cluster (10 participants), Responsible saver cluster (22 participants), Unconcerned spenders cluster (two participants), and Comfort-oriented cluster (17 participants).

if they received these different types of feedback (H1). Additionally, we expected participants assigned to different sustainability clusters to exert different washing behaviors (H2). Lastly, we assumed that participants assigned to different sustainability clusters would respond with different washing behaviors to feedback conveyed in EUR or kWh (H3). While we found significant differences between feedback conditions (H1) manifested in lower washing temperatures, we did not observe significant effects related to sustainability clusters (H2) or the interaction between feedback conditions and sustainability clusters (H3). The lack of significant results from (H2) and (H3) may be attributed to the small sample size used in the analysis. Moreover, it is conceivable that the intention-based screener is not jet capturing clusters that serve as accurate predictors of behavior. Exploring other screening criteria to improve the quality of the clusters might be beneficial. Additionally, participants qualitatively reported that

they experienced habitual changes, felt more informed about the financial impact, and expressed a desire for a more accessible time-preset function. Our findings support the notion that sustainable behavior should be easy and cost-effective and promote habits to be exerted regularly. In the selected sample we found no support for the notion that behavior change interventions should be more individualized. The observed habitual changes in certain participants may indicate the need for a larger sample size to achieve more robust findings. Another possibility is that certain participants may be more amenable to behavior change interventions. The observed differences among individuals may provide insights into the potential for behavior change, potentially leading to the development of more effective approaches and identifiable clusters. From an applied perspective, our research holds implications for the design of products, services, and regulations by governments and companies. With the current pilot

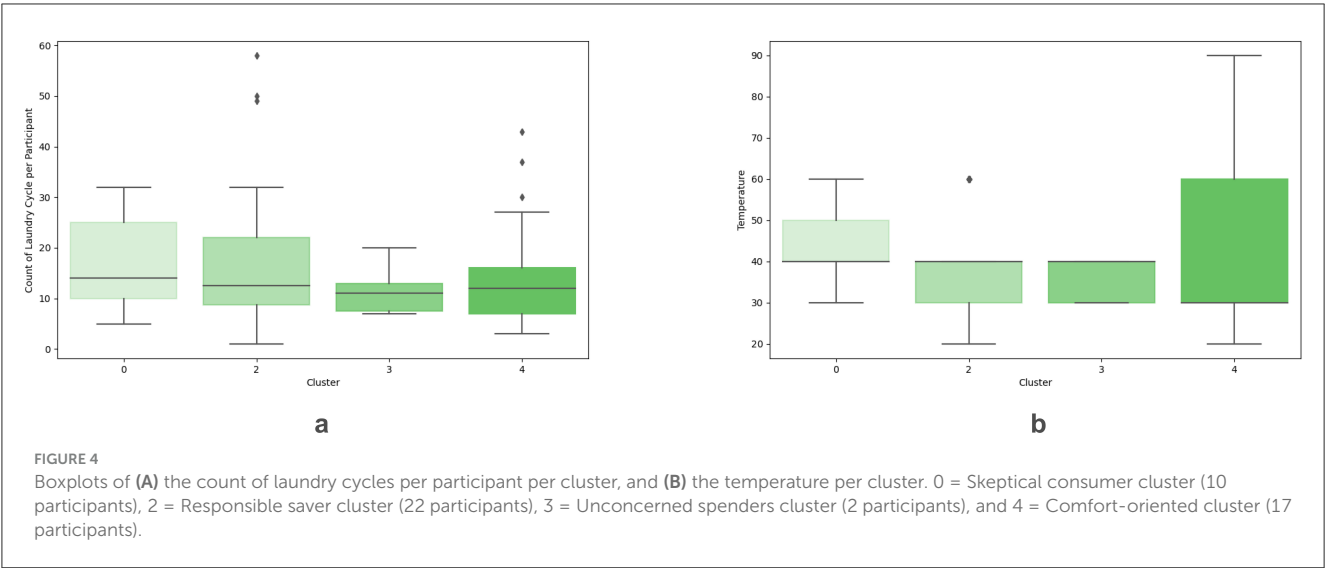


TABLE 5 Interview excerpts from asynchronous interviews.

Category	Quote
Knowledge and interest increase for participants	• No.17 “When the condition with the kWh started, I was quite surprised at how much the consumption is when the washing temperature is lower. I found the difference (...) really immense and was surprised that there was such a big difference, even though it was only 10 degrees.” • No. 30 “I’m going to leave the appliance hanging and try a bit more.”
Behavior change	• No. 1 “No, I don’t think it has changed.” • No.10 “(...) You could see how many more euro now, kWh, etc., were used. That gave me food for thought, and since then we’ve changed so that when I turn on the washing machine, I actually set a timer on my phone to remind me that the washing machine is ready and, ideally, I hang it up straight away.” • No. 20 “The feedback form has definitely changed my washing behavior. (...) this feedback form made me use it for the first time and I’ve actually used it more often since then. I think it’s good because it gives me the opportunity to wash even when the electricity doesn’t cost me anything, namely when the sun is shining.” • No. 32 “Generally no, except for the fact that I probably use this 40-degree eco cotton program more often, which is (...) longer. Otherwise, it hasn’t really changed.”
Backfire effect	• No. 8 “I just have the feeling that I can wash more and it doesn’t make me poor.” • No. 11 “I can simply start half a machine without worrying.”
Try out new programs	• No. 18 “The different forms of feedback (...) made me try out more.” • No. 30 “Now I’ve had some curious fun trying out what the individual programs run for and how they affect consumption at different temperatures.”
Switch to dynamic electricity price	• No. 1 “I would say yes, definitely. If there is potential for savings, we would definitely switch.”
Make it easier to wash sustainably, e.g., via technology	• No. 2 “Eco 40 to 60 degrees written down. That’s simply the display for us. I can’t see exactly what temperature it was set to in the end. That’s why, for example, even when we were washing our baby clothes, we sometimes deliberately used the Hygiene+ program because we definitely wanted 60 degrees.” • No. 17 “(...) I would love smart networking with my cell phone. If I really get a reminder in the morning: Your washing machine is ready” • No. 20 “it would be great if this could be done via an app, e.g., where I could simply set the actual time or perhaps even be able to control it, (...) then I can start the laundry spontaneously.”
Feedback experiment	• No. 5 The euro condition “(...) was more difficult” (to adjust). • No. 32 “I must say the setup was easy for me. It was easy to connect. It was also very well thought out with the energy cost meter holder, so it wasn’t lying around”
Satisfaction with prewash program	• No. 30 “I have a time-preset function in which I can preselect how many hours it should start. I would like to be able to specifically set the time at which it should be ready.”
Feedback on washing machine	• No. 22 “I think this information would be very interesting and useful if the washing machine could tell me how much this wash cycle has just cost me.” • No. 30 “I think a feedback module, which would be integrated into every washing machine from the outset, (...) whether with a green thumb or with a red, sad smiley or something like that, (...) it would make sense to integrate this as a standard function in the washing machine.”

study, we provide reasonable justification to engage in subsequent larger-scale field investigations.

4.1 Implications

From a theoretical perspective, the key findings of our study support the effectiveness of accessibility, and habit formation strategies. Moreover, it is important to consider the potential impact of the feedback effect as a situational factor, in line with the theory of planned behavior (Ajzen, 1985). Feedback has the potential to mitigate the attitude-behavior gap by influencing situational factors. Moderators such as the green product availability and perceived consumer effectiveness can further leverage the attitude-behavior gap (Nguyen et al., 2019). The missing cluster effects do not support the notion of individualization for behavioral change strategies, implicating further research in this area.

Furthermore, most participants reported that they were adopting a more sustainable approach to washing and were willing to switch to a dynamic energy price if it would result in cost savings. A few participants reported washing more carelessly due to the new knowledge of the low cost of a single wash. While the long-term sustainability of these newly adopted habits remains a question, our qualitative findings generally support the argument that sustainable behaviors should be made more accessible. This claim is supported by significant effects on accessibility and habit formation, which were discovered in a meta-study on recycling behavior (Albarracín et al., 2024). Implementation of improved time preset function and enhanced transparency for the cost-benefit of ecological behavior should be a clear focus point for companies to prioritize encouraging users to change their behavior more effectively. Therefore, companies can address behavior change by shifting their design and innovation toward more sustainable products, services, and systems. In addition to reducing dependence on environmentally critical resources, the shift to a more sustainable design might be one of the most promising sustainability aspects. Companies can meet the growing demand for sustainable products by offering eco-friendly and socially responsible options. Hence, this might also raise the danger of greenwashing, which needs to be prevented by the companies and legislation. The shift toward sustainable design enables companies to gain competitive advantages and potentially expand their market share.

5 Limitations

On methodological accounts, *self-reported* studies can be inaccurate due to participant errors and influenced by various biases, such as social desirability bias. Given that washing machines were often located in basements without internet access, using an energy meter with an internet connection to automatically transmit data related to washing behavior to internal secure servers was not possible. Consequently, we were limited to using self-reported data instead of direct behavior monitoring.

In addition, the interviews conducted after the behavioral experiment highlighted issues with the chosen setup, including participants deviating from their regular washing behavior only

due to the feedback conveyed by the energy meter. Besides, *potential backfire effects* occurred due to the newfound knowledge of cost-saving measures, as few participants considered the costs to be very low and reported washing more carelessly because of the study.

The clustering based on a decision tree, as reported in Höpfel et al. (2024), did not perform well on the current study's data. Upon closer inspection of the obtained pattern of results, the *number of subjects* for clustering might have impacted the quantitative part of the study, leading to an uneven distribution between clusters. Therefore, even if our sample is quite representative through the recruitment agency, a larger sample size might yield more impactful results.

Furthermore, our systematic clustering using a short *screening instrument* is based on theory-guided content about sustainable motivations and intentions, which has been validated by Höpfel et al. (2024) using a more extended survey. Nevertheless, the screening procedure is limited because it only contains a narrow set of scales and, therefore, cannot reflect reality, as is usual with shortened versions of longer inventories.

6 Future research

The previously outlined limitations could be addressed in a variety of subsequent experiments. When determining the required sample size for potential follow-up studies, it is crucial to ensure that emerging findings can be backed up in a statistically robust and generalizable manner. Therefore, a larger and more representative sample would help to reduce potential biases and strengthen the results, leading to more accurate and reliable conclusions. Since our research suggests that investigating the impacts of individual characteristics on behavior change is promising, future studies should enhance the methodological approach by utilizing a direct observation strategy. With an internet-connected web app, other household appliances such as the heating system could present an opportunity to further identify common characteristics among sustainable and unsustainable behavior clusters. Consequently, results might help to design and develop effective sustainable behavior change strategies. Additionally, an enhanced screening instrument to determine sustainability clusters seems promising. Since Albarracín et al. (2024) found significant results related to the social component a more explicit focus here could be promising. For example, using a web application where the participant could compare their energy or cost-saving scores within their social community, might contribute additional insights into dynamics related to sustainable thought and action, with a possibility of shifting the perspective from individual consumers to services and communities such as households for behavior change interventions (Tchatchoua et al., 2023).

7 Conclusion

In conclusion, our qualitative results particularly highlighted accessibility, habit formation, and economic components as crucial contributing factors to promoting sustainable behavior. Hence, our quantitative findings demonstrate feedback as a promising

strategy across the entire sample. Since participants assigned to different sustainability clusters did not respond with different washing behaviors we see the need for further studies in individualized behavior change interventions. Results of further studies might enable governments and companies to account for individual factors when assessing the systemic framework influencing consumer behavior. Nevertheless, we found feedback to be an effective behavior change intervention toward mitigating emissions, consequently alleviating the impact on the urgent matter of climate change.

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/un4e7/>.

Ethics statement

The studies involving humans were approved by the ethics committee of the University of Stuttgart [Kommission Verantwortung in der Forschung]: approval number: Az. 23-061. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. ID: Conceptualization, Writing – original draft, Writing – review & editing. FK: Writing – original draft, Writing – review & editing. RW: Writing – original draft, Writing – review & editing. MW: Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing.

References

- Ajzen, I. (1985). "From intentions to actions," in *Action Control*, eds. J. Kuhl and J. Beckmann (Berlin; Heidelberg: Springer), 11–39.
- Albarracín, D., Fayaz-Farkhad, B., and Granados Samayoa, J. A. (2024). *Determinants of Behaviour and Their Efficacy as Targets of Behavioural Change Interventions*. Washington, DC: Nature Reviews Psychology.
- Alborzi, F., Schmitz, A., and Stamminger, R. (2017). Long wash cycle duration as a potential for saving energy in laundry washing. *Nature* 10, 823–838. doi: 10.1007/s12053-016-9486-z
- American Psychological Association (2010). *Ethical Principles and Code of Conduct for Psychologists 2010 Amendments*. (Washington, DC), 65.
- Anaconda Inc. (2020). *Anaconda 3 Software Distribution*. Austin, TX.
- Balmford, A., Bradbury, R. B., Bauer, J. M., Broad, S., and Nielsen, K. S. (2021). *Making More Effective Use of Human Behavioural Science in Conservation Interventions*. Amsterdam: Elsevier.
- Bansal, P. (2005). Evolving sustainably: a longitudinal study of corporate sustainable development. *Soc. Innov.* 26, 197–218. doi: 10.1002/smj.441
- Benjamini, Y., and Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J. Royal Stat. Soc. Ser. B* 57, 289–300.
- Briem, A.-K., Betten, T., Held, M., Wehner, D., and Baumann, M. (2019). Environmental sustainability in the context of mass personalisation—quantification of the carbon footprint with life cycle assessment. *Royal Stat. Soc.* 10, 171–180. doi: 10.24867/IJIEEM-2019-2-237
- Creutzig, F., Niamir, L., Bai, X., Callaghan, M., Cullen, J., Diaz-Jose, J., et al. (2022). Demand-side solutions to climate change mitigation consistent with high levels of well-being. *Change Clim.* 12, 36–46. doi: 10.1038/s41558-021-01219-y
- Dhakal, S., Minx, J. C., Toth, F. L., Abdel-Aziz, A., Figueroa Meza, M. J., Hubacek, K., et al. (2022). *Emissions Trends and Drivers*. Cambridge; New York, NY: University Press Cambridge.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The reported research was funded by the Robert Bosch GmbH and the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy -EXC 2075 - 390740016. We acknowledge the support by the Stuttgart Center for Simulation Science (SimTech).

Acknowledgments

We also acknowledge the use of ChatGPT-3.5 by OpenAI, and Grammarly during the preparation of this work to improve language clarity and readability in the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Conflict of interest

LH, FK and RW were employed by Robert Bosch GmbH, Stuttgart, Germany.

The Robert Bosch GmbH had no involvement in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

The remaining 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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- EU (2016). *European Parliament and Council on the Protection of Natural Persons With Regard to the Processing of Personal Data and on the Free Movement of Such Data, and Repealing Directive 95/46/EC (General Data Protection Regulation)*. Straßburg.
- Grubb, M., Okereke, C., Arima, J., Bosetti, V., Chen, Y., Edmonds, J., et al. (2022). *Introduction and Framing*. Cambridge; New York, NY: Cambridge University Press.
- Hattie, J., and Timperley, H. (2007). The power of feedback. *Rev. Educat. Res.* 77, 81–112. doi: 10.3102/003465430298487
- Hauthal, H. G. (2012). Washing at low temperatures—saving energy, ensuring hygiene. *J. Tenside Surfactants Detergents* 49, 171–177. doi: 10.3139/113.110181
- Hertwig, R. (2017). When to consider boosting: some rules for policy-makers. *Behav. Publ. Pol.* 1, 143–161. doi: 10.1017/bpp.2016.14
- Höpfel, L., Grimlitz, M., Lang, I., and Wirzberger, M. (2024). Promoting sustainable behavior: addressing user clusters through targeted incentives. *Humanit. Soc. Sci. Commun.* 11:1192. doi: 10.1057/s41599-024-03581-6
- Hummel, D., and Maedche, A. (2019). How effective is nudging? a quantitative review on the effect sizes and limits of empirical nudging studies. *J. Behav. Exp. Econ.* 80, 47–58. doi: 10.1016/j.soc.2019.03.005
- Hysong, S. J., Best, R. G., and Pugh, J. A. (2006). Audit and feedback and clinical practice guideline adherence: making feedback actionable. *Implement. Sci.* 1:9. doi: 10.1186/1748-5908-1-9
- Kluyver, T., Ragan-Kelley, B., Pérez, F., Granger, B., Bussonnier, M., Frederic, J., et al. (2016). *Jupyter Notebooks—a Publishing Format for Reproducible Computational Workflows*. Amsterdam: IOS Press.
- Koren, Y., Shpitalni, M., Gu, P., and Hu, S. J. (2015). Product design for mass-individualization. *Opt. Design* 36, 64–71. doi: 10.1016/j.procir.2015.03.050
- Lee, K. (2008). Opportunities for green marketing: young consumers. *Sustainability* 26, 573–586. doi: 10.1108/02634500810902839
- Leiner (2019). *Sosci Survey*. München: SoSciSurvey.
- Lubin, D. A., and Esty, D. C. (2010). The sustainability imperative: lessons for leaders from previous game-changing megatrends. *Harvard Bus. Rev.* 88, 42–50. Available at: <https://hbr.org/2010/05/the-sustainability-imperative>
- MAXQDA (2021). *Computer Software*. Berlin.
- Mohr, L. A., Eroglu, D., and Ellen, P. S. (1998). The development and testing of a measure of skepticism toward environmental claims in marketers' communications. *JSTOR* 32, 30–55. doi: 10.1111/j.1745-6606.1998.tb00399.x
- Nguyen, H. V., Nguyen, C. H., and Hoang, T. T. B. (2019). Green consumption: closing the intention–behavior gap. *Sustain. Dev.* 27, 118–129. doi: 10.1002/sd.1875
- Obermiller, C., and Spangenberg, E. R. (1998). Development of a scale to measure consumer skepticism toward advertising. *Semant. Scholar* 7, 159–186. doi: 10.1207/s15327663jcp070203
- Pakula, C., and Stamminger, R. (2010). Electricity and water consumption for laundry washing by washing machine worldwide. *Nature* 3, 365–382. doi: 10.1007/s12053-009-9072-8
- Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., et al. (2011). Scikit-learn: machine learning in python. *J. Machine Learn. Res.* 12, 2825–2830.
- Shukla, P. R., Skea, J., Slade, R., Al Khourdajie, A., van Diemen, R., McCollum, D., et al. (2022). *Climate Change 2022*. Cambridge: Herausgeber.
- Shute, V. J. (2008). Focus on formative feedback. *Rev. Educat. Res.* 78, 153–189. doi: 10.3102/0034654307313795
- Spencer, J., Lilley, D., and Porter, S. (2015). The opportunities that different cultural contexts create for sustainable design: a laundry care example. *J. Clean. Prod.* 107, 279–290. doi: 10.1016/j.jclepro.2015.04.082
- Steg, L., and de Groot, J. I. M. (2019). *Environmental Psychology, 2nd Edn*. Hoboken, NJ: Wiley.
- Suki, N. M., and Suki, N. M. (2015). Consumption values and consumer environmental concern regarding green products. *Int. J. Sustain. Dev. World Ecol.* 22, 269–278. doi: 10.1080/13504509.2015.1013074
- Tchatchoua, N. S., Boulus-Rødje, N., and Mitchell, V. (2023). Green IT meaning in energy monitoring practices: the case of danish households. *Comput. Support Coop. Work* 3, 1–38. doi: 10.1007/s10606-022-09462-3 have no conflict of interest.
- TestingTime (2023). *Participant Recruitment Company*. Zürich.
- Thaler, R., and Sunstein, C. R. (2008). *Nudge: Improving Decisions about Health*. Nashville, TN: American Economic Association.
- van Rossum, G., and Drake, F. L. (2009). *Python 3 Reference Manual*. Scotts Valley, CA: CreateSpace.
- Vandenbroele, J., Vermeir, I., Geuens, M., Slabbink, H., and van Kerckhove, A. (2020). Nudging to get our food choices on a sustainable track. *Proc. Nutr. Soc.* 79, 133–146. doi: 10.1017/S0029665119000971
- Virtanen, P., Gommers, R., Oliphant, T. E., Haberland, M., Reddy, T., Cournapeau, D., et al. (2020). Scipy 1.0: fundamental algorithms for scientific computing in python. *Nature* 17, 261–272. doi: 10.1038/s41592-019-0686-2
- Vohs, K. D., Mead, N. L., and Goode, M. R. (2006). The psychological consequences of money. *Science* 314, 1154–1156. doi: 10.1126/science.1132491
- Voon, J. P., Ngui, K. S., and Agrawal, A. (2011). Determinants of willingness to purchase organic food: an exploratory study using structural equation modeling. *Res. Agricult. Appl. Econ.* 14, 103–120. doi: 10.22004/ag.econ.103989
- White, K., Habib, R., and Hardisty, D. J. (2019). How to shift consumer behaviors to be more sustainable: a literature review and guiding framework. *J. Market.* 83, 22–49. doi: 10.1177/0022242919825649



OPEN ACCESS

EDITED BY

Christian Andreas Klöckner,
Norwegian University of Science and
Technology, Norway

REVIEWED BY

Ying Zhu,
Xi'an University of Architecture and
Technology, China
Xingdong Wang,
Jiangxi University of Finance and Economics,
China

*CORRESPONDENCE

Qin Chen
✉ qinchen@mail.tsinghua.edu.cn

RECEIVED 12 September 2024

ACCEPTED 14 January 2025

PUBLISHED 12 February 2025

CITATION

Ma H and Chen Q (2025) Social environment,
low-carbon cognition and low-carbon
consumption behaviors of youth groups:
evidence from Xizang, China.
Front. Psychol. 16:1494761.
doi: 10.3389/fpsyg.2025.1494761

COPYRIGHT

© 2025 Ma and Chen. This is an open-access
article distributed under the terms of the
[Creative Commons Attribution License](#)
(CC BY). The use, distribution or reproduction
in other forums is permitted, provided the
original author(s) and the copyright owner(s)
are credited and that the original publication
in this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Social environment, low-carbon cognition and low-carbon consumption behaviors of youth groups: evidence from Xizang, China

Huifang Ma^{1,2} and Qin Chen^{3*}

¹Politics and Public Administration College, Qinghai Nationalities University, Xining, China,

²Guangdong Key Laboratory of Mental Health and Cognitive Science, South China Normal University, Guangzhou, China, ³School of Public Policy and Management, Tsinghua University, Beijing, China

Introduction: Global warming has profoundly transformed the natural environment and significantly impacted people's production methods, thereby promoting low-carbon consumption behaviors. While numerous scholars have examined the factors influencing low-carbon consumption behavior, their analyses predominantly rely on classical theoretical frameworks such as planned behavior theory, value-belief-norm theory and The ABC attitude theory. However, there is a notable scarcity of studies investigating the relationship between the social environment and low-carbon behaviors among youth groups. To address this gap in the literature, we aim to explore how the social environment influences youth groups' low-carbon consumption behaviors, as well as identify the mechanisms through which this influence may manifest.

Methods: This study examines the factors influencing low-carbon consumption behavior from three perspectives: the social environment, low-carbon cognition, and conformity consumption. A theoretical model of low-carbon consumption has been developed, and data were collected through a questionnaire survey involving 600 young individuals in the Xizang Autonomous Region. The hypothesized relationships were tested using structural equation modeling techniques.

Results: The findings indicate that the social environment has a significant positive impact on both low-carbon cognition and behavior. Furthermore, low-carbon cognition is shown to positively influence low-carbon behavior. In terms of the relationship between the social environment and low-carbon behavior, it is found that low-carbon cognition acts as a mediating variable. Additionally, it was observed that lower levels of conformity consumption negatively moderate both the relationship between the social environment and low-carbon behavior as well as that between low-carbon cognition and behavior.

Discussion: These findings suggest that engaging young individuals not only fosters environmental awareness but also promotes sustainable consumption, thereby establishing a solid foundation for the protection and enhancement of our ecological environment. Furthermore, it is essential to disseminate the concept of low-carbon consumerism through various media channels and methodologies. This approach aims to enhance young individuals' understanding of low-carbon principles, guiding them toward more scientifically informed consumption habits while reducing tendencies for blind conformity.

KEYWORDS

the youth group, low-carbon consumption, influence factor, low-carbon cognition, social environment

Introduction

Global warming has not only led to significant alterations in the natural environment but has also affected people's production and lifestyles, resulting in shifts in social structures and prompting systemic changes within economic and social domains. Greenhouse gas emissions, in particular, represent a substantial threat to the global climate and are primarily driven by human activities, whether directly or indirectly (Wang et al., 2024). Global warming is fundamentally reshaping our world. It is now incumbent upon various national governments to prioritize and investigate the issue of climate change, as addressing this challenge is essential for advancing global environmental governance.

Promoting the adoption and maintenance of low-carbon consumption behaviors (LCBs) is a critical component of global climate action (Cheng et al., 2023). The foundation for reducing carbon emissions on the consumption side lies in the low-carbon consumption potential of urban residents. Therefore, it is essential to assess and enhance this potential from a maturity perspective—specifically, by evaluating residents' capabilities and intentions to act responsibly (Wei et al., 2020). Research typically categorizes subjects as urban residents in studies focusing on residents' LCBs (Ding and Li, 2019). However, existing studies are often insufficient. Much of the research examining factors influencing urban residents' low-carbon consumption behavior relies on classical theoretical frameworks such as planned behavior theory, value-belief-norm theory, and ABC theory. Nonetheless, findings tend to vary significantly across different time periods, contexts, and sample populations. Consequently, previous conclusions are challenging to generalize or apply widely within academic literature (Ding et al., 2018).

In practice, China's steadfast commitment to presumptive low-carbon consumption policies provides a robust foundation for further research in this domain. In September 2020, China announced its "double carbon" goals to the international community, making a solemn pledge to peak CO₂ emissions by 2030 and achieve carbon neutrality by 2060 (Zeng et al., 2022). Particularly in the Qinghai-Xizang region—often referred to as the "Third Pole of the Earth" and the "Water Tower of Asia"—it is imperative for residents to adopt a low-carbon lifestyle in order to protect the ecological environment. The Chinese government places significant emphasis on ecological and environmental development within Qinghai-Xizang. For instance, Chinese leaders have visited Xizang numerous times, proposing initiatives to ensure ecological safety while actively exploring models and methods for sustainable economic growth. From this perspective, achieving the "double carbon" target in Tibet presents considerable potential for reducing emissions associated with consumption. Individual low-carbon behaviors are essential for decreasing carbon dioxide emissions and enhancing both environmental quality and ecological health. The advancement of a low-carbon circular economy alongside the adoption of green and low-carbon lifestyles is crucial for attaining high-quality economic development on the Qinghai-Xizang Plateau. As an integral component of a low-carbon economy, consumption patterns play a pivotal role in fostering sustainable development within this region (Zhao et al., 2020; Fan and Fang, 2020).

However, due to the combined effects of global changes and human activities (Fan et al., 2015; Li et al., 2018), the Qinghai-Tibet Plateau is facing challenges such as a decline in ecosystem stability and increasing pressure on resources and the environment (Liu et al., 2021; Fayiah et al., 2020). The rise in temperatures and recurrent episodes of extreme weather events on the Qinghai-Tibet Plateau have

underscored the urgent need for alterations in economic development strategies and lifestyle choices to protect the region's ecological integrity (Sun et al., 2016). Consequently, it is essential to address several key questions regarding low-carbon behaviors (LCBs) within the Qinghai-Tibet region: (1) What factors influence low-carbon consumption behavior in this area? (2) Does the social environment in Qinghai-Xizang facilitate the promotion of low-carbon consumption? (3) Can enhancing awareness of low-carbon consumption lead to improved consumption patterns among residents? These inquiries warrant thorough investigation. Furthermore, as a primary consumer demographic, youth play a pivotal role in shaping concepts and behaviors related to low-carbon consumption. Their influence extends significantly to their peers, parents, and other societal groups (Lin and Jia, 2023; Singh et al., 2020). It is crucial to underscore the role of youth in fostering a social culture that advocates for a green and low-carbon society, while also steering the entire community towards adopting and pursuing sustainable lifestyles (Turner, 1991). In our study, the youth demographic primarily comprises college students who are engaged in undergraduate, associate, and graduate programs at institutions of higher education. Typically aged between 18 and 29, this stage marks a significant transition from adolescence to adulthood. As future pillars of societal development, these young individuals make considerable contributions to societal progress through their involvement in social practices, volunteer services, and various initiatives. By participating in these activities, they leverage their academic knowledge to address social challenges and promote harmonious social development. Therefore, this serves as the primary rationale for our focus on this specific group.

Our study develops a model in which low-carbon consumption serves as the dependent variable, the social environment functions as the independent variable, low-carbon cognition acts as the mediating variable, and conformity consumption is treated as the moderating variable. We have opted to employ and innovate upon the theoretical framework of social impact to more effectively analyze the underlying causes of LCBs in the Qinghai-Tibet region. This paper aims to investigate the influencing factors and driving mechanisms behind low-carbon consumption among young individuals on the Qinghai-Tibet Plateau. The objective is to provide insights that will aid in promoting ecological civilization within this region, advocate for widespread adoption of low-carbon consumption practices among residents, and inform policy formulation aimed at achieving carbon neutrality targets on the Qinghai-Tibet Plateau. In accordance with our research design, we will first summarize existing literature; secondly, we will briefly outline our research methods; next, we will present our research findings; finally, we will discuss these results and draw conclusions from our study.

Literature review and research hypothesis

The impact of social environment on low-carbon cognition and behavior

Based on social learning theory, social interaction serves as a crucial predictor of low-carbon consumption. The impact of socio-environmental factors on college students' behavior is significant and far-reaching (Axsen and Kurani, 2012; Carter, 2017). In this study,

we define “social environment” variables as the collective external social factors that influence individual decisions and actions regarding low-carbon consumption. These factors primarily include concepts related to low carbon practices, relevant technologies, policies, and products. As government attention towards the greenhouse effect and environmental protection intensifies, public understanding of climate change has deepened. This shift has led to an increasing number of young individuals becoming aware of how their personal consumption affects the environment. To foster a more environmentally friendly lifestyle among youth, governments have cultivated a supportive social atmosphere by implementing policy measures for renewable energy and low-carbon products—such as offering tax incentives and establishing environmental rewards (Song et al., 2022).

The emergence of the sharing economy, driven by advancements in science and technology—such as shared bicycles and vehicles—provides convenient low-carbon travel alternatives that align with the consumption patterns of younger generations. This trend significantly impacts their lifestyle choices (Javaid et al., 2020). Moreover, young individuals are highly engaged with social media and are often influenced by peers, family members, friends, and influencers within their social networks (Mi et al., 2019). Conversations about low-carbon consumption within these networks and the broader societal context can positively shape young people’s attitudes toward sustainable practices. Advocacy for low-carbon consumption from peers, idols, and opinion leaders in their circles is likely to capture their attention while enhancing their sense of identity and increasing their willingness to adopt LCBs (Gerbner, 1972; Wang et al., 2021).

Therefore, the influence of the social environment on youth consumption represents a critical factor. When the social environment consistently advocates for low-carbon consumption and fosters a culture of sustainability, young individuals are more likely to adopt this mindset and align their behaviors with societal norms. This may lead them to engage in conspicuous consumption as a means of expressing their individuality. Conversely, when there is minimal emphasis on low-carbon consumption within society, young people tend to be less inclined to embrace environmentally friendly attitudes and behaviors in their consumer choices. It is evident that the cognitive and behavioral patterns of young individuals regarding low-carbon consumption are significantly shaped by the prevailing social atmosphere. Consequently, this study posits that the social environment exerts a substantial positive influence on both the cognitive processes and behaviors related to low-carbon consumption among young individuals.

Building upon these observations, we propose Hypotheses 1 and 2:

H1: The greater the alignment of the social environment towards a cohesive low-carbon atmosphere, the more significantly it can influence the low-carbon cognition of the younger generation.

H2: The greater the alignment of the social environment towards a consistent low-carbon atmosphere, the more significantly it can affect the low-carbon consumption behavior of young individuals.

The effect of low-carbon cognition in LCBs

Cognition refers to the process of acquiring knowledge and understanding events (Barsalou and Lawrence, 2008). An increasing

awareness of issues such as carbon emissions and climate change can lead individuals to become more conscious of the environmental impact of their actions. This heightened awareness further stimulates a sense of social responsibility among individuals, prompting them to adopt low-carbon behaviors. Such behaviors may include optimizing travel methods, reducing plastic consumption, favoring environmentally friendly products and services, and avoiding excessive consumption. Research conducted by Anderson indicates that individuals with greater environmental knowledge significantly influence their environmental awareness and behavior (Anderson et al., 1974). Moreover, social psychology posits that human behavior is shaped by various factors including individual emotions, morality, values, and social norms; among these factors, values play a crucial role in guiding individual conduct (Kashima et al., 2021). According to Ajzen (1991) “theory of planned behavior,” an individual’s beliefs, attitudes, subjective norms, and perceived control all contribute to the formation of their behaviors. The higher residents’ awareness regarding the importance of a low-carbon lifestyle—reflecting appropriate values—the greater their engagement in low-carbon behaviors (Yang et al., 2020).

Low-carbon cognition can significantly influence individual behavior; however, the social environment also plays a pivotal role. The information, values, and norms present within the social context can affect an individual’s acceptance of low-carbon cognition and their propensity to translate it into actionable behavior. By fostering and reinforcing a supportive social environment, individuals are more likely to convert low-carbon cognition into tangible actions. According to Gyberg, a low-carbon social atmosphere—characterized by public education and awareness regarding low-carbon practices—is strongly associated with residents’ adoption of low-carbon energy consumption behaviors (Gyberg and Palm, 2009). By guiding individuals through established social norms and moral emotions to cultivate appropriate values while implementing suitable intervention measures, it is feasible for individuals to consistently alter their previous behaviors (Song et al., 2022). Educational initiatives and public awareness campaigns within the social environment can enhance both the dissemination and understanding of low-carbon cognition while aiding individuals in developing sound environmental protection concepts and practices. Through educational institutions, media outlets, and community organizations embedded in the social fabric, there exists significant potential for effectively promoting the transition from low-carbon cognition to sustainable behavioral change.

Based on this analysis, we propose the following hypothesis:

H3: The low-carbon cognition among the youth demographic positively influences their low-carbon behaviors.

H4: The low-carbon cognition of the youth demographic serves as a mediating factor in the relationship between social and environmental influences and their low-carbon consumption practices.

The moderating effect of conformity consumption

The consumption patterns of young individuals exhibit significant instability and are highly susceptible to the influences of peer groups and social environments (Wang et al., 2021). Under group pressure,

individuals often conform voluntarily to the majority opinion, demonstrating a propensity to align their cognition, perception, and judgment with prevailing public sentiments or behaviors (Banerjee, 1992). They tend to express themselves more freely, embrace new ideas with greater openness, follow trends closely, identify strongly with their peer groups, and display heightened imitation and learning in their behaviors (Hussain et al., 2022; Ali et al., 2021). Conformity can yield both positive and negative outcomes depending on the context in which it occurs (Yu and Sun, 2013). In the domain of consumer behavior, conformity is defined as consumers' inclination to modify their evaluations, purchase intentions, or actual purchasing behaviors under the influence of similar actions exhibited by others (Kang et al., 2019). Research has shown that teenagers' novelty-seeking tendencies, the demonstrative effects of celebrities, and consumers' inclinations to follow trends significantly impact green product consumption (Liu, 2022). Consequently, when low-carbon beliefs or values within a social group converge towards uniformity, varying degrees of conformity may diminish the effect of such consistent beliefs on individual behavior. Studies have indicated that herd mentality negatively moderates the relationship between environmental concern and purchasing behavior (Jingmin and Dong, 2008).

Based on this analysis, we propose the hypothesis 5 and 6:

H5: Conformity in consumption negatively moderates the relationship between the social environment and LCBs, with this effect being mediated by low-carbon cognition.

H6: Conformity in consumption exerts a negative moderating influence on the direct relationship between social-environmental factors and LCBs.

From the analysis presented above, it is evident that the LCBs of young individuals are influenced by a variety of factors. Based on the

logical hypotheses underpinning our research, we have developed a theoretical analytical framework for this study, as illustrated in Figure 1. Within this framework, we delineate the impact relationships among social environment, low-carbon cognition, and LCBs. Additionally, we consider conformity consumption as a moderating variable to investigate its potential contribution to the formation of LCBs.

Data and method

Questionnaire design and measurement

All measurement scales employed in this study were derived from established, validated instruments and were adapted to align with specific cultural contexts (Stern, 2000; Dunlap and Riley, 2008) (See Table 1). The items utilized in this research were evaluated using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), unless otherwise specified.

Data collection

This study utilized a cross-sectional design, concentrating on young college students in the Xizang Autonomous Region of the Qinghai-Xizang Plateau. In April 2022, a total of 100 surveys were distributed for preliminary investigation, with 95 successfully retrieved. The reliability and validity of the survey instrument were confirmed through testing. During the formal investigation, 600 questionnaires were distributed and recovered, yielding a total of 597 responses. The original data was pre-processed using SPSS version 20.0 software. After excluding 35 invalid samples, we retained 562 valid samples, resulting in an effective response rate of 94%. The analysis of these valid samples (refer to Table 3) reveals that the gender and ethnic proportions among respondents are well-balanced.

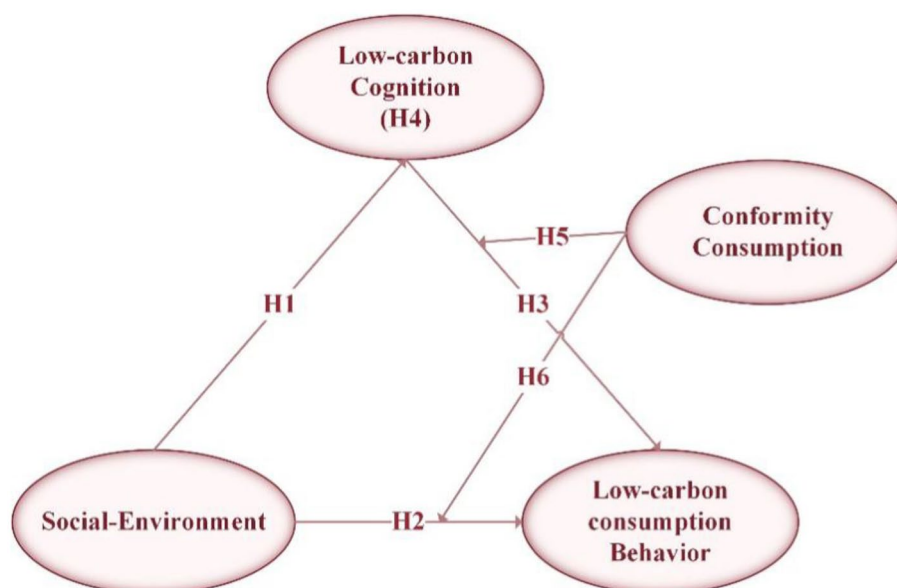


FIGURE 1
Theoretical analysis framework.

TABLE 1 Measurement scales and references.

Latent variable	Indicator	Example item	Reference
Low-carbon cognition (three dimensions, 22 items)	Environmental Awareness (EA)	In my opinion, global warming is primarily caused by excessive carbon dioxide emissions	Bamberg et al. (2003), Chen et al. (2017)
	Low-Carbon Consumption Knowledge (LCCN)		
	Social Responsibility (SR)		
Low-carbon consumption behavior (three dimensions, 20 items)	Low-carbon lifestyle (LCL)	When I travel, I prefer to take the bus or walk rather than take a taxi	Lee et al. (2012)
	Purchasing behavior (PB)		
	Recycling and reusing (RAR)		
Conformity consumption (single dimension, 7 items)	D1-D7	To ensure I purchase the correct brand; I often observe what others are buying and using	Kang et al. (2019), Bearden et al. (1989)
Social environment (single dimension, 7 items)	I1-I7	I may consider purchasing low-carbon products if the government provides substantial subsidies for them	Axsen and Kurani (2012), Song et al. (2022)

Additionally, the household registration locations of participants are widely distributed across agricultural and pastoral areas, reflecting the diverse population distribution densities in Xizang due to historical factors and natural environmental conditions. This indicates that our sample is representative and effectively captures overall characteristics within this demographic group.

Result

To gain a more comprehensive understanding of the interconnected relationships among the various constructs, the proposed theoretical model (Figure 1) was analyzed using structural equation modeling. Initially, an assessment of the measurement model encompassing all latent constructs and indicators was performed, followed by an evaluation of the hypothesized structural model.

Validity, reliability, and fit testing

The Cronbach's α values for each latent variable exceed 0.765, with specific values of 0.924, 0.899, and 0.881 for the respective variables, indicating satisfactory internal consistency ($\alpha > 0.765$). Reliability and validity results are shown in Table 2.

The load values for low-carbon consumption behavior are 0.583, 0.526, and 0.547, reflecting high consistency among the three factors in the scale. For low-carbon cognition, the load values are 0.636, 0.809, and 0.787, demonstrating strong component consistency as well. The factor loadings between each latent variable and its measurement index range from 0.52 to 0.80; both combined reliability (CR) exceeds 0.6 and average variance extracted (AVE) surpasses 0.5 (see Table 2). These findings indicate robust explanatory power within this questionnaire's dimensions and affirm its validity. We assessed overall model fit with favorable results: CMIN/df = 2.399 < 3; RMSEA = 0.048 < 0.08; GFI = 0.927 > 0.900; TLI = 0.91 > 0.900; CFI = 0.923 > 0.900—most indices suggest strong explanatory power.

Using Harman's single-factor exploratory analysis via SPSS software to assess common method bias revealed that the first factor

explains only 15% of variance without rotation—well below the significant threshold of 40%. This indicates a low level of common methodological bias. The root mean square of AVE values for all latent variables exceeds their correlation coefficients with other variables, suggesting robust discriminant validity among selected latent variables.

LCBs under the influence of the social environment

A simple mediation model was employed to investigate the mediating effect of low-carbon cognition on the relationship between social environment and LCBs while controlling for gender and grade (see Tables 4, 5). The results indicate that the social environment significantly predicts LCBs. Furthermore, even when accounting for the mediating role of low-carbon cognition, this predictive effect remains significant. Additionally, the social environment exerts a substantial influence on low-carbon cognition, which in turn significantly predicts LCBs. Moreover, both the direct effect of social environment on LCBs and the mediating effect of low-carbon cognition yield a bootstrap confidence interval at 95% that does not include zero. This finding suggests that not only can the social environment directly predict LCBs but it can also do so indirectly through its influence on low-carbon cognition.

Following this, we adjusted the latter half of the mediation model and the direct path. The mediated model was analyzed while controlling for gender and grade. The findings indicate that when incorporating the regulatory variable of conformity consumption into the model, both the interaction term between social environment and conformity consumption, as well as the interaction term between low-carbon cognition and conformity consumption, exhibit significant predictive effects on low-carbon behaviors (LCBs). Furthermore, the standardized path coefficient is negative, indicating a substantial adverse impact. This suggests that conformity consumption not only negatively moderates the direct influence of social environment on low-carbon consumption behavior but also adversely affects the role of low-carbon cognition in predicting low-carbon consumption behavior through mediating variables.

TABLE 2 Validation and reliability testing.

Latent variable	Indicator	Standardized factor loading	CR	AVE	Cronbach's α
Low-carbon cognition	EA	0.636	0.898	0.524	0.924
	LCCN	0.809	0.882	0.517	
	SR	0.787	0.883	0.520	
Low-carbon Consumption behavior	LCL	0.583	0.911	0.508	0.899
	PB	0.526	0.891	0.505	
	RAR	0.547	0.866	0.519	
Conformity consumption	D1	0.662	0.880	0.512	0.881
	D2	0.698			
	D3	0.719			
	D4	0.690			
	D5	0.719			
	D6	0.702			
	D7	0.808			
Social- environment	I1	0.759	0.982	0.519	0.765
	I2	0.628			
	I3	0.640			
	I4	0.757			
	I5	0.792			
	I6	0.647			
	I7	0.1796			

EA, Environmental Awareness; LCCN, Low-Carbon Consumption Knowledge; SR, Social Responsibility; LCL, Low-Carbon Lifestyle; PB, Purchasing Behavior; RAR, Recycling and Reusing.

Further combined with a simple slope analysis (see [Figure 2](#)), it was found that the impact of the social environment on low-carbon consumption behavior, as well as the influence of the social environment mediated by low-carbon cognition on low-carbon consumption behavior, is contingent upon levels of conformity. A high level of conformity in consumption exhibits a weaker moderating effect (95% CI: -0.152 to 0.503 , -0.133 to 0.165). In contrast, a low level of conformity in consumption demonstrates a significant negative moderating effect (95% CI: 0.304 to 0.720 , 0.164 to 0.420). The results indicate that lower levels of conformity in young people's consumption are associated with diminished influences from the social environment on their LCBs; similarly, reduced levels of conformity also correlate with decreased impacts from the social environment mediated by low-carbon cognition on their LCBs.

This finding aligns with previous studies ([Lim et al., 2023](#)). Conformity refers to the tendency of individuals to be influenced by group behaviors, perspectives, or values in order to adhere to group norms or expectations. Low levels of conformity indicate that individuals are less susceptible to the influence of societal groups and are more likely to engage in independent thought and action. For those exhibiting low conformity, the impact of the social environment on their low-carbon consumption behavior is either weak or virtually non-existent. Similarly, among young people with low levels of conformity, there is a diminished effect of the social environment mediated by low-carbon cognition when predicting their low-carbon consumption behavior. Conversely, no significant moderating effect is observed for young individuals displaying high levels of conformity.

Discussion and conclusion

Based on data collected from 600 young individuals in the Qinghai-Xizang Plateau, this study examines and theoretically analyzes the relationship between low-carbon behaviors (LCBs) and three latent variables: social-environmental factors associated with low-carbon consumption, low-carbon cognition, and conformity behavior within youth groups. Six research hypotheses are proposed. Through hypothesis testing utilizing structural equation modeling analysis, the results indicate that the model is valid and supports all six research hypotheses. The analysis reveals that: (1) The social environment positively influences both the low-carbon cognition and LCBs of young people; (2) Low-carbon cognition has a positive effect on the LCBs of young individuals; (3) Low-carbon cognition serves as a mediating variable in the relationship between social environment and LCBs among youth. Furthermore, it is found that (4) at lower levels of conformity among young people, there exists not only a negative moderating effect on the direct influence of social environment on low-carbon consumption behavior but also a detrimental moderation of the intermediary variable—low-carbon cognition—on LCBs. For youth group LCBs, both social environment and low-carbon cognition emerge as critical variables. It is essential to recognize that individual levels of conformity exert varying effects on these two variables' influences and should not be overlooked.

The youth population plays a pivotal role as both participants and leaders in the future of social development, with their consumption

TABLE 3 Descriptive statistics.

Variables	Category	Frequency (N)	Percent (%)
Gender	Male	230	40.9
	Female	332	59.1
Grade	Freshman	143	25.4
	Sophomore	176	31.3
	Junior	153	27.2
	Senior	90	16
Ethnicity	Han	176	31.3
	Zang	376	66.9
	Other	10	1.8
Home location	City	72	12.8
	Town	147	26.2
	Agricultural and pastoral area	343	61
Household registration location	Urban	99	17.6
	Rural	463	82.4
Source of living expenses	Support from parents and family	490	87.2
	Work and study on your own	34	6
	Tutoring or vacation job	23	4.1
	School grants or scholarships	15	2.7

TABLE 4 Results of the hypothesis test.

Path	B	β	SE	t	p
Social-environment → low-carbon cognition	0.511	0.599	0.062	8.2	***
Low-carbon cognition → low-carbon consumption behavior	0.157	0.247	0.055	2.849	0.004
Social-environment → low-carbon consumption behavior	0.189	0.349	0.051	3.702	***
Low-carbon cognition x conformity consumption → low-carbon consumption behavior	−0.117	−0.218	0.034	−3.413	***
Conformity consumption → low-carbon consumption behavior	−0.055	−0.117	0.028	−2.007	0.045
Social-environment x conformity consumption → low-carbon consumption behavior	−0.084	−0.151	0.034	−2.454	0.014

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

concepts and behavioral habits significantly influencing this trajectory. By engaging in low-carbon consumption practices, young individuals can cultivate environmental awareness and sustainable consumption

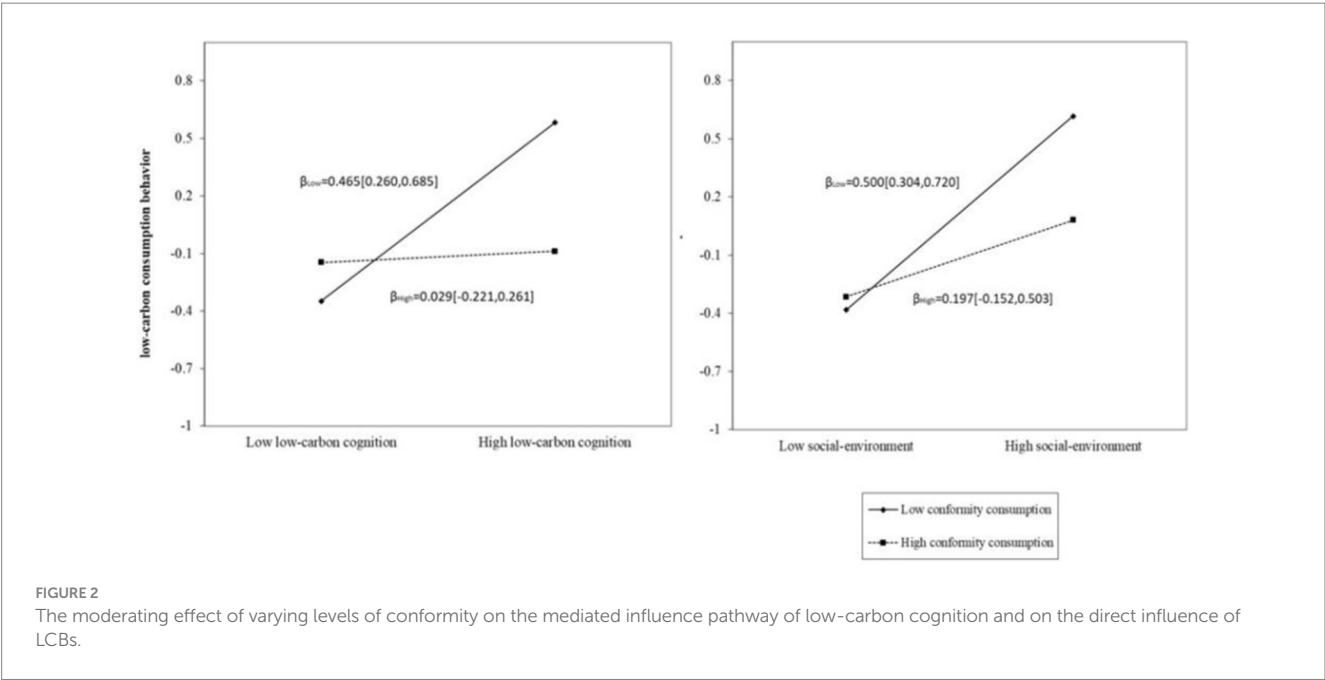
principles, thereby establishing a solid foundation for the protection and enhancement of the ecological environment in the future. Simultaneously, as consumers, the choices made by young people will shape market demand. By opting for environmentally friendly and low-carbon products and services, they can incentivize businesses to expedite their transition towards green production methods. This shift not only promotes carbon reduction but also fosters ecological preservation on the production side (Liu et al., 2019). The Qinghai-Tibet Plateau serves as a crucial ecological barrier within China; thus, safeguarding its ecological environment is imperative. Consequently, actively promoting a low-carbon economy while encouraging young people to participate in low-carbon consumption practices will positively contribute to achieving sustainable development goals. In light of these insights, this article proposes several strategies and recommendations aimed at enhancing Low-Carbon Behaviors (LCBs) among youth in the Qinghai-Tibet Plateau region: specifically targeting other social groups to foster widespread adoption of LCBs that align with achieving “dual carbon” objectives.

Firstly, the social environment exerts a direct and positive influence on the low-carbon behaviors (LCBs) of young individuals. As members of society, young people continuously adjust their actions to align with their social surroundings, which includes aspects such as conformity and socialization. Peer pressure within this environment also significantly affects individual behavior (Mi et al., 2019). When the social atmosphere collectively fosters a consistent culture of low-carbon consumption, it profoundly encourages young people’s behavioral choices in this regard. Therefore, enhancing the LCBs among youth should commence with an emphasis on improving the social environment; this represents a crucial entry point for addressing this issue. The social environment serves as a pivotal factor influencing young individuals and primarily manifests through its role in guiding and exemplifying rational low-carbon consumption practices among college students via a cohesive societal atmosphere. An increase in factors that advocate for and promote low-carbon consumption within the community will provide more exemplary models and accurate guidance regarding consumption concepts for young people (Yin and Shi, 2021). Even if individuals lack comprehensive knowledge about low-carbon practices, they are likely to follow trends toward sustainable consumption when society uniformly endorses such behaviors. Conversely, if societal attitudes towards low-carbon consumption are negative or if there is an absence of robust external support for these initiatives, it can adversely affect young people’s engagement with sustainable practices. Thus, advocating for low-carbon principles and promoting environmentally friendly consumerism emerge as critical variables shaped by societal contexts. In advancing a low-carbon economy and encouraging eco-friendly products within the Qinghai-Xizang Plateau region, it is imperative to widely disseminate the concept of low-carbon consumerism through diverse media channels and methods while fostering participation from all segments of society to cultivate a unified atmosphere that supports LCBs.

Secondly, low-carbon cognition can directly predict the low-carbon consumption behaviors of young people and simultaneously serves as a mediating factor in the relationship between social-environmental influences and the low-carbon behaviors (LCBs) of this demographic. Consequently, low-carbon cognition plays a pivotal role in shaping LCBs among youth. By

TABLE 5 Test results of the moderating effect.

Path	Conformity levels	Effect	Bootstrapping 95%CI	
			Lower	Upper
Mediation path				
Social-environment → low-carbon cognition → low-carbon consumption behavior	Low	0.279	0.164	0.420
	High	0.018	−0.133	0.165
Direct path				
Social-environment → low-carbon consumption behavior	Low	0.500	0.304	0.720
	High	0.197	−0.152	0.503



enhancing their understanding of low-carbon principles, young individuals can grasp the impact of carbon emissions on the environment, recognize how their consumption choices relate to these emissions, and learn strategies for reducing carbon footprints through altered consumption habits and selecting green products. This awareness fosters a deeper appreciation for the significance of adopting a low-carbon lifestyle while bolstering environmental consciousness and willingness to take action (Xia et al., 2018). Moreover, cultivating low-carbon awareness is essential for transforming LCBs. It motivates young people to actively opt for low-carbon products and services during their purchasing activities, thereby contributing positively to environmental protection efforts and carbon reduction initiatives (Hu et al., 2021). Additionally, low-carbon cognition shapes youths' attitudes toward sustainable consumption practices as well as their sense of social responsibility; they perceive such actions as vital avenues for engaging in environmental stewardship and promoting sustainable development. A positive orientation towards low-carbon principles not only enhances young people's

knowledge about sustainability but also cultivates an affirmative ecological value system that guides them in transitioning from traditional high-carbon consumption patterns to more sustainable lower-carbon lifestyles.

Finally, this study found that the behavior of conforming to others directly influences low-carbon behaviors (LCBs) within the social environment. Furthermore, the social environment characterized by low-carbon cognition serves as a mediator and exerts a negative moderating effect on LCBs. Further analysis revealed that when conformity levels among young individuals are low, there is a detrimental moderating effect on the relationship between these two factors. The trait of conformity can exhibit both positive and negative dimensions, contingent upon the context and its implications. In certain circumstances, conformity may facilitate individuals in learning and adapting to new environments, information, or cultures by allowing them to acquire valuable experiences and knowledge from others. This trait increases an individual's likelihood of becoming an influencer in social change by leading trends and group behaviors, which can

yield positive societal impacts. However, excessive conformity may result in blind imitation and herd mentality, ultimately impairing independent thinking abilities and judgment while rendering individuals susceptible to misinformation or harmful behaviors. A study examining motivations for healthy food choices indicated that demand driven by health consciousness—rational decision-making based on an objective understanding of dietary health—is relatively stable (Ding and Li, 2019). Whereas the consumption of organic food, influenced by conformity psychology, often exhibits fluctuations in response to changing consumer trends, resulting in greater instability (Wang et al., 2023). Among youth groups, there are more pronounced manifestations of comparison-based consumption phenomena that may lead to irrational behaviors such as blind conformity in consumption patterns devoid of self-awareness. For instance, the pursuit of novelty or uniqueness during consumption processes—without regard for practical value—could adversely affect more rational and scientifically informed low-carbon behaviors (LCBs). Therefore, when guiding young individuals on the Qinghai-Tibet Plateau towards adopting LCBs, it is imperative for governments to enhance the promotion of low-carbon knowledge while effectively raising awareness about environmental issues within this demographic group.

Continuously enhancing their understanding of low-carbon concepts will guide individuals toward scientific rationality in their consumption habits while mitigating blind conformist behaviors. Elevated levels of low-carbon awareness can empower individuals to make more rational and independent sustainable consumption decisions. Low-carbon awareness plays a pivotal role in promoting sustainable consumption practices, irrespective of the influence exerted by societal factors.

If young people acquire accurate knowledge regarding what constitutes “low-carbon” and comprehend the interdependence between human production activities and environmental climate resources, they will be motivated to adopt pro-low carbon consumption inclinations. To engage effectively in low-carbon consuming practices, it is essential to understand what defines “low-carbon” and which types of consumption qualify as “low-carbon.” Additionally, recognizing the interrelationship between human activities and environmental climate resources is crucial. Only then can individuals diminish non-independent preferences such as blind adherence or ostentation, thereby fostering a collective commitment to being rational, persistent practitioners and advocates for sustainable low-carbon consumption practices.

However, it is essential to acknowledge the limitations of this study. The research primarily concentrates on young individuals and does not address other demographic groups. We recognize that college students constitute only a subset of this broader demographic. While college students may exhibit distinct characteristics regarding social influences, cognitive development, and consumption patterns, they also represent a significant segment of the youth population—particularly in studies examining behavioral change and consumption trends. We believe that their inclusion offers valuable insights into the wider youth demographic; however, we recommend that future research explore additional subgroups within the youth population, such as non-college youths or young professionals, to further assess the generalizability of our findings. Lastly, the analysis of LCBs in this study predominantly

focuses on individual consciousness while neglecting the influence of public policies. In conclusion, future research will continue to emphasize these areas.

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

Author contributions

HM: Writing – original draft. QC: Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This paper was supported by the Postdoctoral Fellowship Program of CPSJ (GZC20231228). The Ministry of Education Key Laboratory of Brain, Cognition and Educational Sciences (South China Normal University) for funding this groundbreaking project.

Acknowledgments

Thanks to the Ministry of Education Key Laboratory of Brain, Cognition and Educational Sciences (South China Normal University) for funding this groundbreaking project.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Ajzen, I. (1991). The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50, 179–211. doi: 10.1016/0749-5978(91)90020-T
- Ali, M., Amir, D. H., and Shamsi, D. A. (2021). Consumer herding behavior in online buying: a literature review. *Int. Rev. Manag. Bus. Res.* 10, 345–360. doi: 10.30543/10-1(2021)-30
- Anderson, W. T., Henion, K. E., and Cox, E. P. (1974). Socially versus ecologically responsible consumers. *Am. Mark. Assoc. Comb. Conf. Proc.* 36, 304–311.
- Axsen, J., and Kurani, K. S. (2012). Social influence, consumer behavior, and low-carbon energy transitions. *Annu. Rev. Environ. Resour.* 37, 311–340. doi: 10.1146/annurev-environ-062111-145049
- Bamberg, S., Ajzen, I., and Schmidt, P. (2003). Choice of travel mode in the theory of planned behavior: the roles of past behavior, habit, and reasoned action. *Basic Appl. Soc. Psychol.* 25, 175–187. doi: 10.1207/S15324834BASP2503_01
- Banerjee, A. V. (1992). A simple model of herd behavior. *Q. J. Econ.* 107, 797–817. doi: 10.2307/2118364
- Barsalou, L., and Lawrence, W. (2008). Grounded cognition. *Annu. Rev. Psychol.* 59, 617–645. doi: 10.1146/annurev.psych.59.103006.093639
- Bearden, W. O., Netemeyer, R. G., and Teel, J. E. (1989). Measurement of consumer susceptibility to interpersonal influence. *J. Consum. Res.* 15, 473–481. doi: 10.1086/209186
- Carter, I. (2017). Human behavior in the social environment: A social systems approach. London: Routledge.
- Chen, F., Chen, H., Guo, D., and Long, R. (2017). Analysis of undesired environmental behavior among Chinese undergraduates. *J. Clean. Prod.* 162, 1239–1251. doi: 10.1016/j.jclepro.2017.06.051
- Cheng, X., Long, R., Wu, F., Geng, J., and Yang, J. (2023). How social interaction shapes habitual and occasional low-carbon consumption behaviors: evidence from ten cities in China. *Renew. Sust. Energy Rev.* 182:113387. doi: 10.1016/j.rser.2023.113387
- Ding, Z., Jiang, X., Liu, Z., Long, R., Xu, Z., and Cao, Q. (2018). Factors affecting low-carbon consumption behavior of urban residents: a comprehensive review. *Resour. Conserv. Recycl.* 132, 3–15. doi: 10.1016/j.resconrec.2018.01.013
- Ding, A. W., and Li, S. (2019). Herding in the consumption and purchase of digital goods and moderators of the herding bias. *J. Acad. Mark. Sci.* 47, 460–478. doi: 10.1007/s11747-018-0619-0
- Dunlap, R. E., and Riley, E. (2008). The new environmental paradigm scale: from marginality to worldwide use. *J. Environ. Educ.* 40, 3–18. doi: 10.3200/JOEE.40.1.3-18
- Fan, Y., and Fang, C. (2020). Insight into carbon emissions related to residential consumption in Tibetan plateau—case study of Qinghai. *Sustain. Cities Soc.* 61:102310:102310. doi: 10.1016/j.scs.2020.102310
- Fan, J., Xu, Y., Wang, C., Niu, Y., Chen, D., and Sun, W. (2015). The effects of human activities on the ecological environment of Tibet over the past half century. *Chin. Sci. Bull.* 60, 3057–3066. doi: 10.1360/N972014-01311
- Fayiah, M., Dong, S., Khomera, S. W., Ur Rehman, S. A., Yang, M., and Xiao, J. N. (2020). Status and challenges of Qinghai–Tibet Plateau's grasslands: an analysis of causes, mitigation measures, and way forward. *Sustain. For.* 12:1099. doi: 10.3390/su12031099
- Gerbner, G. (1972). Communication and social environment. *Sci. Am.* 227, 152–160. doi: 10.1038/scientificamerican0972-152
- Gyberg, P., and Palm, J. (2009). Influencing households' energy behaviour—how is this done and on what premises? *Energy Policy* 37, 2807–2813. doi: 10.1016/j.enpol.2009.03.043
- Hu, X., Wu, N., and Chen, N. (2021). Young people's behavioral intentions towards low-carbon travel: extending the theory of planned behavior. *Int. J. Environ. Res. Public Health* 18:2327. doi: 10.3390/ijerph18052327
- Hussain, M., Sadiq, S., Rasheed, M. H., and Amin, K. (2022). Exploring the dynamics of investors' decision making in Pakistan stock market: a study of herding behavior. *J. Econ. Impact.* 4, 165–173. doi: 10.52223/jei4012220
- Javadi, A., Creutzig, F., and Bamberg, S. (2020). Determinants of low-carbon transport mode adoption: systematic review of reviews. *Environ. Res. Lett.* 15:103002. doi: 10.1088/1748-9326/aba032
- Jingmin, W., and Dong, W. (2008). Cognition research on global climate change. *China Popul. Resour. Environ.* 18, 58–63. doi: 10.1016/S1872-583X(09)60008-5
- Kang, I., Cui, H., and Son, J. (2019). Conformity consumption behavior and FoMO. *Sustainability* 11:4734. doi: 10.3390/su11174734
- Kashima, Y., O'Brien, L., McNeill, I., Ambrose, M., Bruce, G., Critchley, C. R., et al. (2021). Low carbon readiness in social context: introducing the social context of environmental identity model. *Asian J. Soc. Psychol.* 24, 169–183. doi: 10.1111/ajsp.12454
- Lee, Y. K., Choi, J. G., Kim, M. S., Ahn, Y. G., and Katz-Gerro, T. (2012). Explaining pro-environmental behaviors with environmentally relevant variables: a survey in Korea. *Afr. J. Bus. Manag.* 6:102310:102310. doi: 10.5897/AJBM11.2360
- Li, S., Zhang, Y., Wang, Z., and Li, L. (2018). Map human influence intensity in the Tibetan plateau for conservation of ecological service functions. *Ecosyst. Serv.* 30, 276–286. doi: 10.1016/j.ecoser.2017.10.003
- Lim, S., Seetaram, N., Hosany, S., and Li, M. (2023). Consumption of pop culture and tourism demand: through the lens of herding behaviour. *Ann. Tourism Res.* 99:103531. doi: 10.1016/j.annals.2023.103531
- Lin, B., and Jia, H. (2023). The role of peers in promoting energy conservation among Chinese university students. *Humanit. Soc. Sci. Commun.* 10, 1–10. doi: 10.1057/s41599-023-01682-2
- Liu, Y. (2022). Research on the influencing factors of herd consumption behavior in the context of e-commerce live streaming. *Int. Conf. Internet E-Bus.* 14–21:101337. doi: 10.1145/3545897.3545900
- Liu, Y., Liu, R., and Jiang, X. (2019). What drives low-carbon consumption behavior of Chinese college students? The regulation of situational factors. *Nat. Hazards* 95, 173–191. doi: 10.1007/s11069-018-3497-3
- Liu, W. H., Zheng, J. W., Wang, Z. R., Li, R., and Wu, T. H. (2021). A bibliometric review of ecological research on the Qinghai–Tibet plateau, 1990–2019. *Ecol. Inform.* 64:101337:101337. doi: 10.1016/j.ecoinf.2021.101337
- Mi, L., Zhu, H., Yang, J., Gan, X., Xu, T., Qiao, L., et al. (2019). A new perspective to promote low-carbon consumption: the influence of reference groups. *Ecol. Econ.* 161, 100–108. doi: 10.1016/j.ecolecon.2019.03.019
- Singh, P., Sahadev, S., Oates, C. J., and Alevizou, P. (2020). Pro-environmental behavior in families: a reverse socialization perspective. *J. Bus. Res.* 115, 110–121. doi: 10.1016/j.jbusres.2020.04.047
- Song, Y., Zhang, L., and Zhang, M. (2022). Research on the impact of public climate policy cognition on low-carbon travel based on SOR theory—evidence from China. *Energy* 261:125192. doi: 10.1016/j.energy.2022.125192
- Stern, P. C. (2000). New environmental theories: toward a coherent theory of environmentally significant behavior. *J. Soc. Issues* 56, 407–424. doi: 10.1111/0022-4537.00175
- Sun, W., Mu, X., Song, X., Wu, D., Cheng, A., and Qiu, B. (2016). Changes in extreme temperature and precipitation events in the loess plateau (China) during 1960–2013 under global warming. *Atmospheric Res.* 168, 33–48. doi: 10.1016/j.atmosres.2015.09.001
- Turner, J. C. (1991). Social influence. Pacific Grove, CA: Thomson Brooks Cole Publishing Co.
- Wang, T., Shen, B., and Ma, T. (2024). Individual low-carbon behaviors and influencing factors: insights from a behavior survey study in China. *Heliyon* 10:e31094. doi: 10.1016/j.heliyon.2024.e31094
- Wang, T., Shen, B., Springer, C. H., and Hou, J. (2021). What prevents us from taking low-carbon actions? A comprehensive review of influencing factors affecting low-carbon behaviors. *Energy Res. Soc. Sci.* 71:101844. doi: 10.1016/j.erss.2020.101844
- Wang, J., Xue, Y., and Liu, T. (2023). Consumer motivation for organic food consumption: health consciousness or herd mentality. *Front. Public Health* 10:1042535. doi: 10.3389/fpubh.2022.1042535
- Wei, J., Chen, H., Long, R., Zhang, L., and Feng, Q. (2020). Maturity of residents' low-carbon consumption and information intervention policy. *J. Clean. Prod.* 277:124080. doi: 10.1016/j.jclepro.2020.124080
- Xia, L., Hao, W., Qin, J., Ji, F., and Yue, X. (2018). Carbon emission reduction and promotion policies considering social preferences and consumers' low-carbon awareness in the cap-and-trade system. *J. Clean. Prod.* 195, 1105–1124. doi: 10.1016/j.jclepro.2018.05.255
- Yang, Y., Guo, Y., and Luo, S. (2020). Consumers' intention and cognition for low-carbon behavior: a case study of Hangzhou in China. *Energies* 13:5830. doi: 10.3390/en13215830
- Yin, J., and Shi, S. (2021). Social interaction and the formation of residents' low-carbon consumption behaviors: an embeddedness perspective. *Resour. Conserv. Recycl.* 164:105116. doi: 10.1016/j.resconrec.2020.105116
- Yu, R., and Sun, S. (2013). To conform or not to conform: spontaneous conformity diminishes the sensitivity to monetary outcomes. *PLoS One* 8:e64530. doi: 10.1371/journal.pone.0064530
- Zeng, N., Jiang, K., Han, P., Hausfather, Z., Cao, J., Kirk-Davidoff, D., et al. (2022). The Chinese carbon-neutral goal: challenges and prospects. *Adv. Atmos. Sci.* 39, 1229–1238. doi: 10.1007/s00376-021-1313-6
- Zhao, Y., Chen, D., and Fan, J. (2020). Sustainable development problems and countermeasures: a case study of the Qinghai–Tibet plateau. *Geogr. Sustain.* 1, 275–283. doi: 10.1016/j.geosus.2020.11.002



OPEN ACCESS

EDITED BY

Christian Andreas Klöckner,
Norwegian University of Science and
Technology, Norway

REVIEWED BY

Nida Hussain,
Zhengzhou University, China
Bindu Shrestha,
Kathmandu University, Nepal

*CORRESPONDENCE

Youji Kohda
✉ kohda@jaist.ac.jp

RECEIVED 04 June 2024

ACCEPTED 11 February 2025

PUBLISHED 04 March 2025

CITATION

Hnin SW, Javed A, Karnjana J, Jeenanunta C
and Kohda Y (2025) Workplace sustainability:
energy-saving behaviors in office
environments of Thailand.
Front. Psychol. 16:1400410.
doi: 10.3389/fpsyg.2025.1400410

COPYRIGHT

© 2025 Hnin, Javed, Karnjana, Jeenanunta
and Kohda. This is an open-access article
distributed under the terms of the [Creative
Commons Attribution License \(CC BY\)](#). The
use, distribution or reproduction in other
forums is permitted, provided the original
author(s) and the copyright owner(s) are
credited and that the original publication in
this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Workplace sustainability: energy-saving behaviors in office environments of Thailand

Su Wutyi Hnin^{1,2}, Amna Javed¹, Jessada Karnjana³,
Chawalit Jeenanunta² and Youji Kohda^{1*}

¹School of Management Technology, Sirindhorn International Institute of Technology, Thammasat University, Pathum Thani, Thailand, ²School of Knowledge Science, Japan Advanced Institute of Science and Technology, Nomi, Japan, ³Intelligent System Research Group, NECTEC, National Science and Technology Development Agency, Pathum Thani, Thailand

Introduction: Energy consumption in office environments significantly impacts global energy usage, particularly due to lighting, air conditioning, and electronic devices. Urbanization and economic growth in Thailand exacerbate energy demands, positioning office environments as essential for energy conservation efforts. Traditional strategies have primarily focused on technological solutions, but these approaches often fail to address the pivotal role of human behavior in shaping energy consumption.

Methods: This study develops a culturally contextualized framework by integrating the Motivation-Opportunity-Ability (MOA) model, the Norm Activation Model (NAM), and the Theory of Planned Behavior (TPB) to examine key determinants of workplace energy-saving behavior. Data were collected from 105 office workers in Bangkok, Thailand, through an online survey. Using Partial Least Squares Structural Equation Modeling (PLS-SEM), this study validated the framework to analyze the relationships between motivation, opportunity, ability, intention, and behavior within hierarchical workplace structures and collective decision-making settings.

Results: The results highlight motivation and ability as significant predictors of energy-saving behavior, reinforcing the role of awareness of consequences, personal norms, and perceived control. However, opportunity, intention, and individual comfort exhibit negative relationships with energy-saving behavior, suggesting that structural policies, behavioral intentions, and thermal satisfaction interact in complex ways.

Conclusion: These findings underscore the importance of contextually adaptive workplace policies that account for behavioral and structural energy conservation challenges. By providing a culturally sensitive framework, this study offers insights for policymakers and organizational leaders to develop effective and sustainable energy-saving strategies that integrate behavioral considerations alongside technological interventions.

KEYWORDS

energy-saving behavior, ability–motivation–opportunity model, norm activation model, theory of planned behavior, structural equation modeling

1 Introduction

Energy consumption in office environments constitutes significant global energy use, driven by lighting, air conditioning, and electronic devices. As hubs of economic and professional activity, office buildings present substantial energy conservation opportunities (Xu et al., 2020; Mantesi et al., 2022). In Thailand, where rapid urbanization and economic growth have intensified energy demands, office environments play a key role in

achieving national energy efficiency goals. Efforts to reduce energy consumption in offices have primarily focused on technological solutions, such as energy-efficient lighting and automated HVAC systems, which have shown measurable success. However, these methods often overlook the critical role of human behavior in shaping energy consumption patterns. Behavioral interventions, such as awareness campaigns and reminders, have also been employed but frequently lack the contextual relevance and specificity needed to influence sustained energy-saving practices, particularly in diverse and culturally nuanced settings like Thailand (Su et al., 2022; Akhound et al., 2022). Recent research has provided valuable insights but reveals significant gaps in understanding energy-saving behaviors in office environments. Akhound et al. (2022) explored employees' intentions to reduce workplace energy consumption, highlighting the influence of employee attitudes and perceived organizational support. However, their findings lacked integration with theoretical models that comprehensively explain behavioral drivers. Similarly, Su et al. (2022) examined the role of organizational energy-saving culture using system dynamics modeling, emphasizing the importance of fostering an energy-conscious culture while neglecting motivational and psychological factors. Xu et al. (2020) studied the impact of social norms. They ascribed responsibility for energy-saving behaviors across different office layouts, identifying behavioral variations linked to workplace design but failing to integrate these findings with broader behavioral theories, such as the Theory of Planned Behavior (TPB). Mantesi et al. (2022) analyzed post-pandemic energy consumption trends in office environments, emphasizing the importance of adaptive energy management strategies but noting the lack of focus on individual employee behaviors. These studies collectively highlight the need for a comprehensive framework that integrates individual, social, and organizational factors to address the unique challenges of energy conservation in office environments, particularly in Thailand. This research addresses these gaps by integrating the Motivation-Opportunity-Ability (MOA) framework with constructs from the Norm Activation Model (NAM) and TPB to develop a holistic model for understanding energy-saving behaviors in office environments. This study uses Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze survey data collected from office workers in Thailand. The proposed framework examines how ability, motivation, opportunity, and behavioral intentions interact while incorporating external organizational influences such as workplace culture and social norms. By focusing on office environments in Thailand, the research provides culturally contextualized insights into energy-saving practices, extending the applicability of global behavioral theories to regional and organizational contexts. The contributions of this research are four-fold. Theoretically, it advances workplace sustainability studies by integrating three well-established behavioral models—MOA, NAM, and TPB—into a unified framework. Methodologically, it demonstrates the utility of PLS-SEM in analyzing complex relationships between individual and organizational factors in office settings. Practically, it provides actionable recommendations for policymakers and organizational leaders to design effective energy-saving interventions tailored to office workers' motivations and workplace dynamics. Contextually, it bridges global theories with Thailand's unique cultural and

managerial practices, offering a framework to guide energy conservation strategies in diverse office environments. These contributions aim to promote more effective and sustainable energy-saving practices in Thailand and beyond. The remainder of the article is structured as follows: Section "Related works" defines the research framework and hypotheses, focusing on energy-saving behaviors in office workplaces. Section "Research framework and hypothesis" presents the research methods and data collection process. Section "Analysis of data and results" analyzes the data and results, while Section "Discussion and implications" discusses the findings and implications. Finally, Section "Conclusion" concludes the study and outlines potential directions for future research.

2 Related works

2.1 Energy consumption in office environments

Energy consumption in office environments accounts for a substantial portion of global energy use, primarily driven by the demand for lighting, air conditioning, and electronic devices. Office buildings, as centers of economic and professional activity, offer significant opportunities for energy conservation. Technological interventions such as Personalized Environmental Control Systems (PECS) and advanced dimming systems have shown promise in optimizing energy efficiency. Bian and Hu (2024) conducted a study that utilized neural networks to optimize dimming technologies, achieving a balance between visual comfort and energy efficiency. Organizational strategies also play a vital role in conservation efforts. Su et al. (2022) emphasized the importance of fostering an energy-conscious workplace culture, which can significantly reduce consumption through behavioral change. As Mantesi et al. (2022) examined, post-pandemic hybrid work models further underscore adaptive energy management's importance in accommodating shifting office usage patterns. Behavioral aspects remain critical in achieving energy efficiency. Li et al. (2019) applied the Motivation-Opportunity-Ability (MOA) framework, demonstrating how individual and organizational factors shape energy-saving behaviors. Weerasinghe et al. (2023) highlighted the social psychological dynamics influencing occupant energy-related behaviors, particularly the interplay of peer influence and managerial support in fostering sustainable practices.

2.2 Behavioral frameworks in energy conservation

Behavioral theories such as the MOA framework, Norm Activation Model (NAM), and Theory of Planned Behavior (TPB) have been extensively used to explain energy-saving behaviors in office environments. The MOA framework emphasizes motivation, opportunity, and ability as key action enablers. Li et al. (2019) demonstrated its effectiveness in fostering energy-saving behaviors by linking employee motivation with organizational enablers. However, it underrepresents social and normative influences such as moral responsibility and peer accountability (Zhang et al.,

2024). NAM offers a complementary perspective by focusing on personal norms and moral responsibility as drivers of pro-environmental behavior. Tverskoi et al. (2021) found that moral responsibility and social norms significantly impact employees' willingness to adopt energy-saving behaviors. However, NAM's limited consideration of external organizational enablers restricts its applicability to complex workplace settings (Weerasinghe et al., 2023). The TPB bridges some of these gaps by incorporating attitudes, subjective norms, and perceived behavioral control. Xu et al. (2020) applied TPB to understand energy-saving intentions in office layouts, demonstrating the role of perceived control and peer norms in shaping workplace behaviors. Integrated frameworks that combine elements of these models have shown promise. Li et al. (2019) proposed a unified framework integrating MOA's actionable enablers, NAM's moral dimensions, and TPB's emphasis on social influences. Zhang et al. (2024) supported this approach, illustrating how integrated models enhance the understanding of both individual and collective drivers of energy-saving behaviors. From a practical standpoint, behavioral interventions rooted in psychological theories have succeeded (Shrestha et al., 2021). Kotsopoulos et al. (2018) showed that tailored gamification strategies aligned with workplace dynamics significantly engage employees in energy-saving actions. Similarly, Carrus et al. (2021) emphasized psychological predictors, such as intentions and awareness, as critical to designing interventions that promote sustainable practices.

2.3 Cultural and regional contexts: focus on Thailand

Cultural and regional dynamics significantly influence energy-saving behaviors, particularly in Thailand, where socioeconomic structures intersect with cultural norms. Donovan et al. (2016) linked higher education and environmental awareness to the increased adoption of sustainable practices in Thailand. Hnin et al. (2024) highlighted the dominance of cost-saving motivations over ecological concerns. These findings emphasize the need for culturally tailored interventions that address practical and environmental motivations. Office environments in Thailand present unique behavioral dynamics. Apipuchayakul and Vassanadumrongdee (2020) demonstrated that cultural attitudes and perceived behavioral control strongly influence the adoption of energy-efficient practices. Similarly, Jareemit and Limmeechokchai (2019) identified socio-economic factors, such as education and income, as critical determinants of energy-saving behaviors in Bangkok households. Environmental factors further shape adaptive behaviors. Iamtrakul et al. (2020) highlighted that urban heat islands in Thai cities encourage energy-saving practices such as reduced air conditioning use.

2.4 Identified gaps and modified integrated framework

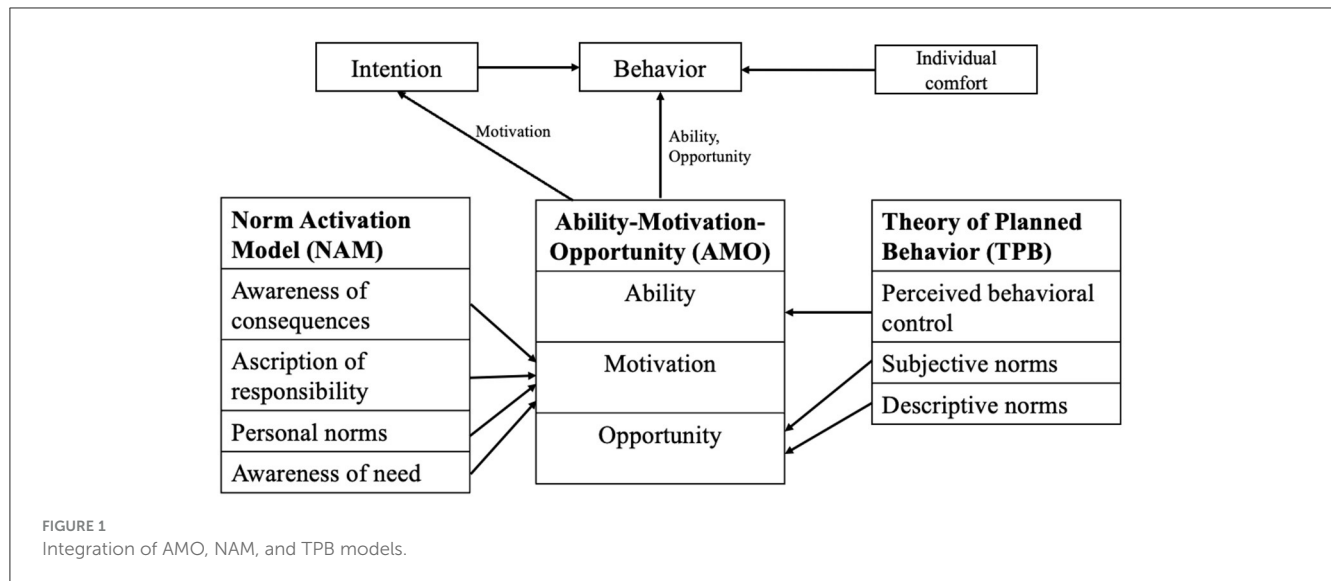
Despite advancements in understanding energy-saving behaviors, significant gaps persist, particularly in integrating

psychological, organizational, and cultural dimensions into comprehensive theoretical models. Frameworks such as the MOA model, NAM, and TPB provide valuable insights but exhibit limitations when applied in isolation. For instance, MOA highlights external enablers and individual abilities but neglects moral and normative influences critical for sustained behavior change (Li et al., 2019). Similarly, NAM emphasizes personal moral responsibility and social norms yet overlooks external organizational enablers and structural opportunities essential in workplace settings (Zhang et al., 2024). TPB extends these models by incorporating subjective norms and perceived behavioral control but lacks attention to cultural and contextual factors that shape behaviors in specific regions, such as Thailand (Xu et al., 2020; Hnin et al., 2024). Thai workplaces present unique challenges due to hierarchical structures, collective decision-making, and cost-saving priorities, significantly influencing energy-saving behaviors (Apipuchayakul and Vassanadumrongdee, 2020; Hnin et al., 2024). Additionally, environmental factors, such as urban heat islands, remain underexplored in existing frameworks but play a critical role in shaping energy use decisions in Thailand's urban office environments (Iamtrakul et al., 2020). These gaps highlight the need for a more contextually sensitive and comprehensive framework. This study proposes a modified integrated framework that builds on MOA, NAM, and TPB while introducing novel elements to address these limitations. The framework incorporates cultural moderators, such as hierarchical workplace structures, to reflect regional dynamics' influence better. It also integrates organizational factors, such as peer influence and energy-saving culture, alongside external environmental considerations like hybrid work arrangements and thermal comfort. By capturing these interactions, the modified framework bridges gaps in the literature and offers actionable insights for designing tailored energy-saving interventions in Thai office environments.

3 Research framework and hypothesis

3.1 Research framework

The study employs a modified integrated framework synthesizing the MOA, NAM, and TPB models to understand energy-saving behaviors in office environments comprehensively. The MOA model emphasizes the interplay of motivation, opportunity, and ability, highlighting the role of external enablers and individual capabilities in influencing workplace behaviors. While MOA captures structural and organizational factors, it lacks consideration of moral and normative dimensions, which the NAM addresses. NAM explains pro-environmental behavior through constructs such as awareness of need, awareness of consequences, ascription of responsibility, and personal norms, making it particularly relevant in contexts where moral responsibility drives action. However, NAM does not consider external and organizational factors crucial in workplace settings. TPB complements these models by integrating subjective norms, descriptive norms, and perceived behavioral control to predict intentions and behaviors, bridging the gap between individual decision-making and organizational dynamics. Despite its utility, TPB often underrepresents intrinsic motivations and cultural



variations. The proposed framework addresses the limitations of existing models by building upon the Theory of Planned Behavior (TPB) and incorporating cultural moderators, such as hierarchical workplace structures and collective decision-making processes, alongside contextual factors like thermal comfort and hybrid work arrangements. Although TPB integrates subjective norms, descriptive norms, and perceived behavioral control to predict intentions and behaviors, it often underrepresents intrinsic motivations and cultural variations. By including these additional dimensions, the framework effectively captures Thailand's unique environmental and organizational nuances, providing a more comprehensive approach to understanding energy-saving behaviors. The integrated framework comprises five key constructs: Motivation, Opportunity, Ability, Intention, and Individual Comfort. Motivation encapsulates intrinsic psychological drivers, including personal norms, awareness of need, ascription of responsibility, and awareness of consequences, which collectively shape behavioral intention. Intention functions as a mediating mechanism, converting motivational forces into tangible energy-saving behaviors. Opportunity, conceptualized through subjective and descriptive norms, moderates the motivation-intention relationship by incorporating external social and organizational influences. Ability, defined through the construct of perceived behavioral control, delineates an individual's capacity to execute energy-saving actions, exerting a direct influence on behavior while reinforcing the impact of intention. Individual comfort serves as a critical contextual moderator, particularly within Thailand's hot and humid subtropical climate, where energy conservation efforts—such as minimizing air conditioning usage—may conflict with workplace thermal satisfaction. The perceived behavioral control component within the TPB framework further refines the conceptualization of Ability, integrating both physical capacity and the perceived feasibility of performing energy-efficient behaviors. Workplace energy conservation is often contingent on practical considerations; office workers may exhibit reluctance to engage in such practices if they perceive them as burdensome or

disruptive to their workflow. By synthesizing these constructs, the proposed framework provides a holistic and contextually adaptive model for understanding energy-saving behaviors in office environments. Figure 1 visually delineates the interrelationships among these constructs, demonstrating the integration of the MOA, NAM, and TPB models into a unified theoretical structure that accounts for individual, social, and environmental determinants of workplace energy conservation. The integrated research framework of the private companies in Thailand is shown in Figure 2.

3.2 Research hypothesis

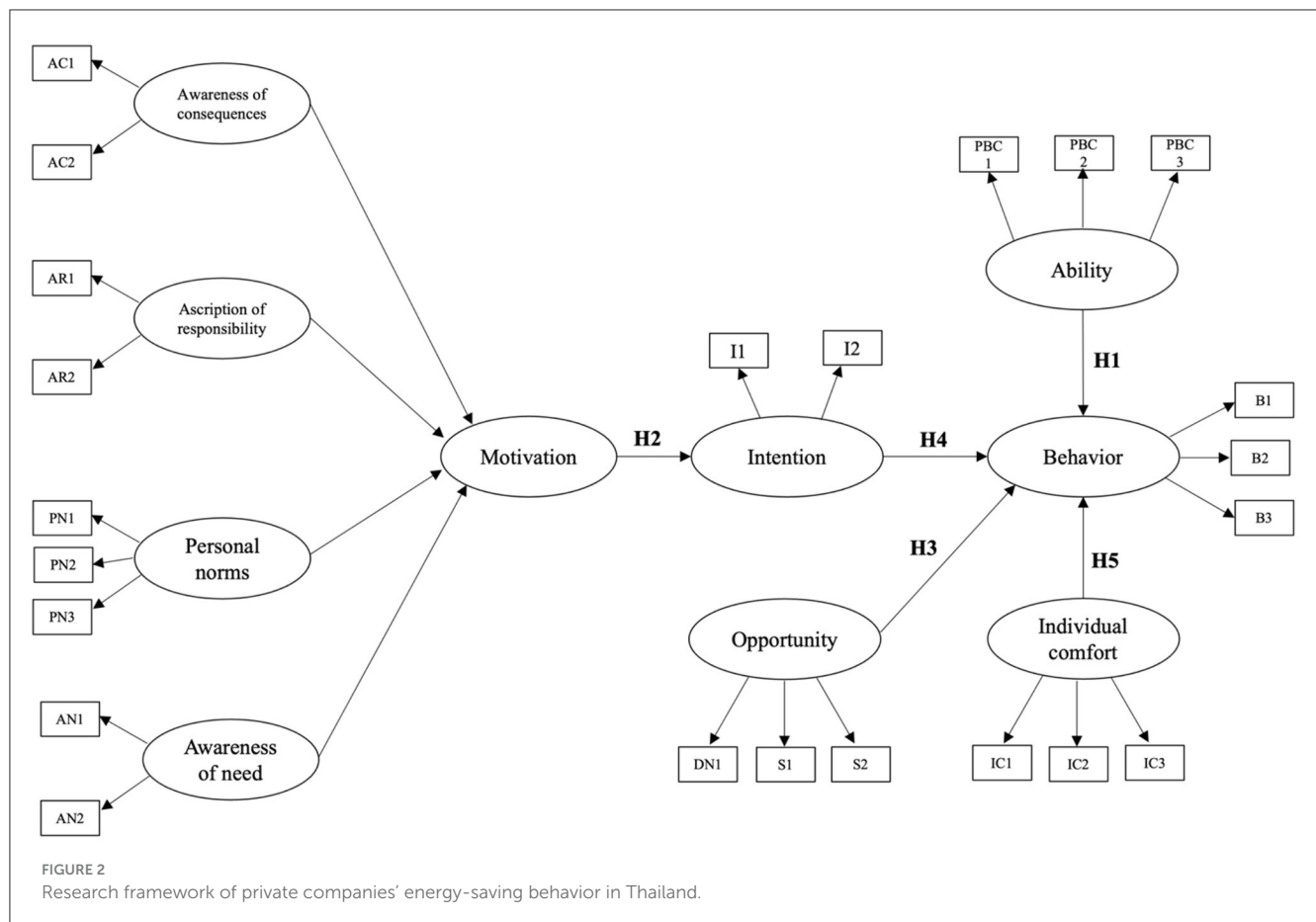
3.2.1 Ability

Ability is the competency to perform a particular mental or physical act or an existing skill and the basic and psychological physical abilities to achieve an outcome (Shi et al., 2017). The PBC of the TPB is used to represent ability as a measurable (Fornara et al., 2016) and indicates the difficulty or ability to perform a single behavior (Fornara et al., 2016; Wang et al., 2018) has made a significant contribution to raising awareness about energy-saving. Workers may be reluctant to save energy in the workplace when the behavior requires physical effort.

Hypothesis 1. Ability has a direct and positive impact on energy-saving behavior.

3.2.2 Motivation

Motivation is usually considered a force that steers individuals toward goals in desired behaviors (Michie et al., 2011). It captures workers' values, needs, participation, and preoccupation in the workplace to represent behavior. Three of the constructs from the NAM are used as social-psychological factors in motivation: personal norms, awareness of consequences, and



ascription of responsibility (Kim et al., 2018). Personal norms act as a way of self-testing and an intake requirement to engage in pro-environmental or pro-social behavior. Awareness of need highlights the importance of recognizing the necessity or requirement for a particular behavior, which influences decision-making (Deci and Ryan, 2000). Awareness of consequence features the main construct, expectancy, that affirms the behavior of expectancy drives, which plays an important role in the theory of motivation based on cognition. Ascription of responsibility also plays an important role in motivation theory as a cognitive component (Lopes et al., 2019).

Hypothesis 2. Motivation has a direct and positive impact on intention.

3.2.3 Opportunity

Opportunity refers to an external factor that either inhibits or activates behavior. It integrates interpersonal and environmental factors that limit or facilitate energy-saving behaviors at work. Subjective norms of the TPB are used to treat opportunity as a measurable component. Subjective norms are whether most people disagree or agree with energy-saving behavior. Descriptive norms have also been included as an additional construct in TPB (Forward, 2009). Descriptive norms determine one's beliefs about the behavior of others (Conner et al., 2003).

Hypothesis 3. Opportunity has a direct and positive impact on energy-saving behavior.

3.2.4 Intention

Intention is a fundamental determinant of behavior, representing the level of eagerness individuals possess in making decisions to act. In workplace energy conservation, intention signifies individuals' readiness to turn off unused electronic devices, reduce energy consumption, or adopt energy-efficient practices. It is generally assumed that individuals with strong intentions are more likely to translate their readiness into actual energy-saving behaviors, provided that enabling conditions align with their goals. Understanding intention is critical as it bridges motivational and contextual factors, offering insights into how cognitive and environmental influences shape workplace energy-saving practices (Chai and Baudelaire, 2015).

Hypothesis 4. Intention has a direct and positive impact on energy-saving behavior.

3.2.5 Individual comfort

Saving energy to the detriment of an individual's comfort is not ideal. Individual comfort and energy savings are closely tied together. Setting an energy-saving approach into action at the cost of an individual's comfort was

difficult, depending on the discussion of the individual concept of the trade-off between energy-saving and thermal comfort (Li et al., 2019).

Hypothesis 5. Individual comfort has a direct and positive impact on energy-saving behavior.

3.3 Summary of hypotheses

The hypotheses proposed in this study provide a structured basis for examining the interplay of psychological, organizational, and contextual factors influencing energy-saving behaviors within workplace settings. The first hypothesis posits that ability, defined as the availability of physical and psychological resources, directly and positively affects energy-saving behavior. Equipping individuals with the necessary skills and tools enables effective energy conservation efforts. The second hypothesis emphasizes motivation as a key driver of intention, incorporating intrinsic factors such as personal norms, moral responsibility, and awareness of consequences, which collectively inspire proactive energy-saving decisions. Opportunity, as conceptualized in the third hypothesis, refers to external enablers such as supportive policies and organizational structures posited to facilitate energy-saving behavior. The fourth hypothesis examines the relationship between intention and behavior, asserting that strong intentions predict consistent implementation of energy-saving practices, though practical barriers may occasionally mediate this relationship. Finally, the fifth hypothesis addresses the role of individual comfort, suggesting that perceived discomfort, particularly in thermal environments, may serve as a trade-off that dampens engagement in energy-saving actions. Together, these hypotheses frame the study's analytical approach, enabling a comprehensive exploration of the factors underpinning energy conservation in culturally nuanced and workplace-specific contexts.

3.4 Data collection

This study employed an online survey via Google Forms to gather data from participants working in various private companies in Bangkok, Thailand. The survey link was distributed to company managers, who disseminated it within their organizations. Bangkok was selected as the research site due to its rapid urbanization and prominence as an economic hub, where office buildings significantly contribute to energy consumption. The survey was carried out over 2 months, yielding 105 valid responses. The questionnaire consisted of two sections: the first focused on demographic information, while the second assessed key constructs such as ability, motivation, opportunity, intention, and energy-saving behavior. The survey items were adapted from validated scales in previous studies to ensure consistency and reliability. This data collection method provided a comprehensive dataset for evaluating the proposed modified integrated framework through Partial Least Squares Structural Equation Modeling (PLS-SEM).

TABLE 1 Survey item.

Constructs	Description
Energy-saving behaviors	How often do you turn off the following devices when they are not in use for saving energy? (1) Light; (2) Computer; (3) Air conditioner (AC).

3.5 Questionnaire design

The questionnaire was divided into two sections. The first section asked for demographic information such as gender, age, education level, and income, and the second section addressed the major measures of this study in the following sequence.

1. Behavioral measures (e.g., turning off electronic devices when they are not in use; see Table 1).
2. Ability (perceived behavioral control; see Table 2).
3. Motivation (personal norms, ascription of responsibility, awareness of consequences, and awareness of need; see Table 2).
4. Opportunity (subjective norms, descriptive norms; see Table 2).
5. Intention (Table 2).
6. Individual comfort (Table 2).

The measures were taken from previous studies (Carrico and Riemer, 2011; Chen and Knight, 2014; Li et al., 2019; Xu et al., 2020). The variables were evaluated on a five-point Likert scale, with a minimum of one and a maximum of five. Table 2 shows the integrated model's survey structure and detailed measures.

3.6 Data analysis method

The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), a method well-suited for testing complex models and small sample sizes. SmartPLS 3.0 software was used to perform the analysis, which followed a two-step approach (Wong, 2013). First, the measurement model was evaluated to ensure the reliability and validity of the constructs. Reliability was assessed using Cronbach's alpha and composite reliability, while convergent validity was examined through the average variance extracted. Discriminant validity was tested using the Heterotrait-Monotrait (HTMT) ratio to ensure that constructs were distinct. The second step evaluated the structural model to test the hypothesized relationships between constructs. Path coefficients, effect sizes, and the coefficient of determination (R^2) were calculated to assess the strength and significance of these relationships. Bootstrapping with 5,000 resamples was conducted to ensure statistical robustness.

4 Analysis of data and results

The PLS-SEM analysis was conducted using SmartPLS, evaluating both the measurement and structural models. The measurement model assessed the validity and reliability of latent constructs, while the structural model examined the relationships between independent and dependent variables (MacCallum and

TABLE 2 Measurement items for constructs.

Constructs	Item no.	Items
Intention	I1	1. I will try to save energy in my workplace.
	I2	2. I am willing to save energy in my workplace.
Individual comfort	IC1	1. I am satisfied with the temperature in my workplace.
	IC2	2. I am satisfied with the light in my workplace.
	IC3	3. I am satisfied with the indoor environment of my workplace.
Ability		
1. Perceived behavioral control	PCB1	1. Increasing energy-saving behavior in the workplace is entirely within my control.
	PCB2	2. I am confident that I can save energy in the workplace if I want to.
	PCB3	3. I have the knowledge and skills to save energy in the workplace.
Motivation		
1. Awareness of consequences	AC1	1. When I reduce electricity use in my workplace, I am doing something good.
	AC2	2. When I reduce electricity use in my workplace, I am reducing costs.
2. Ascription of responsibility	AR1	1. I feel responsible for the energy use in the workplace.
	AR2	2. I feel responsible for reducing energy use in the workplace.
3. Personal norm	PN1	1. I feel good about myself when I do not use a lot of energy.
	PN2	2. I feel guilty when I use a lot of energy in the workplace.
	PN3	3. I think I have a responsibility to save energy in the workplace.
4. Awareness of Need	AN1	1. Energy saving in my workplace can contribute the sustainability of our society.
	AN2	2. Energy saving in my workplace contributes to alleviating energy shortage issues.
Opportunity		
1. Subjective norms	S1	1. Most of my colleagues expect me to turn off the computer when leaving.
	S2	2. Most of my colleagues expect me to turn off the light when leaving.
2. Descriptive norms	D1	1. The management team has taken actions to save energy.

Browne, 1993). The measurement model was assessed to ensure the reliability and validity of the constructs before proceeding with the structural model analysis. All constructs met the required thresholds for composite reliability (CR), Cronbach's alpha, average variance extracted (AVE), and discriminant validity, confirming

the robustness of the measurement model. The structural equation modeling (PLS-SEM) analysis provided statistical support for all hypothesized relationships; however, three constructs—opportunity, intention, and individual comfort—exhibited negative directional effects on energy-saving behavior.

4.1 Descriptive statistics

The study surveyed 105 office workers in various private-sector organizations across Thailand, capturing a diverse demographic representative of modern Thai office environments. The gender distribution was balanced, with 50.5% male and 49.5% female respondents. Age groups were well-distributed, with the majority (38.1%) aged between 35 and 45 years, followed by 31.5% aged 25–35. Educational attainment was predominantly at the bachelor's level (66.6%), with 18.1% holding master's degrees. These figures align with the profile of urban professionals in Thailand's private sector. Monthly income levels ranged primarily from 15,000 to 30,000 Baht (56.2%), a demographic reflective of middle-class office workers. Participants' professional roles included mid-level administrators (45%), managers (35%), and technical staff (20%), ensuring a robust representation of organizational hierarchies and responsibilities. This demographic distribution provides a strong contextual foundation for examining the interplay of individual, organizational, and cultural influences on energy-saving behaviors in Thai office environments. Survey findings reveal that most participants demonstrated a strong commitment to energy-saving practices, as reflected in a mean intention score of 4.2 on a 5-point scale. Approximately 85% of respondents reported high levels of awareness about energy conservation, scoring 4 or above, and 72% acknowledged a personal sense of responsibility for contributing to energy-saving actions. The construct of ability, which represents perceived behavioral control and confidence in implementing conservation measures, achieved a mean score of 3.9, indicating moderate confidence among participants. Opportunity, measuring external support and organizational enablers, received a lower mean score of 3.5, with 55% of respondents agreeing that their workplace provided sufficient resources and policies to support energy-saving behaviors, indicating potential structural and organizational support gaps.

4.2 Model validation

4.2.1 Reliability and convergent validity

Ensuring the reliability and validity of constructs is fundamental to the robustness of the theoretical framework. Reliability was assessed using Cronbach's alpha and composite reliability (CR), which evaluates the internal consistency of measurement scales. Cronbach's alpha values exceeding the 0.70 threshold indicate that the items within each construct reliably measure the intended dimension. Composite reliability further validates this by accounting for shared variance among indicators. Convergent validity was evaluated using average variance extracted (AVE), with a threshold of 0.50, indicating that the construct explains a substantial portion of variance. Table 3 provides the

TABLE 3 Reliability and validity.

	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Ability	0.761	0.768	0.542
Ascription of responsibility	0.763	0.821	0.696
Awareness of consequence	0.744	0.847	0.735
Behavior	0.79	0.821	0.635
Motivation	0.913	0.93	0.628
Opportunity	0.747	0.757	0.517
Personal norm	0.853	0.901	0.695

reliability and validity results, confirming that all constructs exceeded the recommended thresholds. For instance, motivation achieved a Cronbach's alpha of 0.913, a CR of 0.930, and an AVE of 0.628, demonstrating its strong reliability and convergent validity. Similarly, constructs such as Personal Norms and Ascription of Responsibility also performed well, with AVE values of 0.695 and 0.696, respectively. These results confirm that the constructs are robust and aligned with the theoretical framework.

4.2.2 Discriminant validity

Discriminant validity ensures that constructs are distinct and measure unique theoretical dimensions. The Heterotrait-Monotrait (HTMT) ratio was used to assess discriminant validity, with values below 0.85 confirming that constructs are conceptually separate. Table 4 presents the HTMT ratios, indicating satisfactory discriminant validity for all constructs. For example, the HTMT value between Motivation and Intention was 0.794, confirming a strong yet distinct relationship. These findings underscore the theoretical clarity and conceptual robustness of the model.

4.3 Path analysis

The hypothesized relationships were all statistically significant ($p < 0.01$), confirming their relevance within the model. However, three relationships, opportunity, intention, and individual comfort with energy-saving behavior, demonstrated negative effects, diverging from the conventional directional expectations. These relationships are depicted in Figure 3, which provides a visual representation of the validated pathways among the constructs. Additionally, Table 5 presents the effect sizes (f^2) associated with each relationship, offering further insight into the practical significance of the findings. The pathway from ability to energy-saving behavior was positive and statistically significant ($\beta = 0.308$, $p < 0.001$), with a large effect size ($f^2 = 1.02$). This result underscores the pivotal role of perceived control in facilitating pro-environmental behaviors. Similarly, the motivation to intention relationship was strongly positive ($\beta = 0.762$, $p < 0.001$), accompanied by a medium-to-large effect size ($f^2 = 0.582$). These findings align with existing literature on the influence of personal

norms and awareness of consequences in shaping sustainability-related intentions in the workplace. In contrast, the opportunity to energy-saving behavior relationship exhibited an unexpected negative effect ($\beta = -0.419$, $p < 0.001$), with an effect size of $f^2 = 0.33$. This suggests that contextual factors, such as workplace policies or social norms, may be perceived as constraints rather than enablers of energy-saving behaviors. The intention to energy-saving behavior relationship also demonstrated a negative effect ($\beta = -0.304$, $p < 0.01$), with an effect size of $f^2 = 0.24$. This points to the presence of an intention-behavior gap, where stated intentions do not always translate into actual behavior, potentially due to competing priorities or external constraints. Finally, the individual comfort to energy-saving behavior relationship was negative ($\beta = -0.356$, $p < 0.01$), with an effect size of $f^2 = 0.31$. This indicates that office workers' prioritization of thermal and visual comfort may hinder their engagement in energy-saving practices, in line with adaptive thermal comfort models that highlight the trade-off between energy efficiency and perceived well-being. The results presented in Figure 3, together with the effect sizes detailed in Table 5, provide strong empirical support for the integrated framework. These findings offer valuable insights into the complex interplay of motivational, contextual, and personal factors in shaping energy conservation efforts within Thai office environments.

4.4 Hypothesis testing

The hypothesis testing results, summarized in Table 6, provide empirical validation for the framework. Although all hypotheses were statistically supported, the negative direction of H3, H4, and H5 challenges conventional behavioral models. These findings indicate that opportunity, intention, and comfort do not always function as enablers of energy conservation but can, under certain conditions, act as constraints.

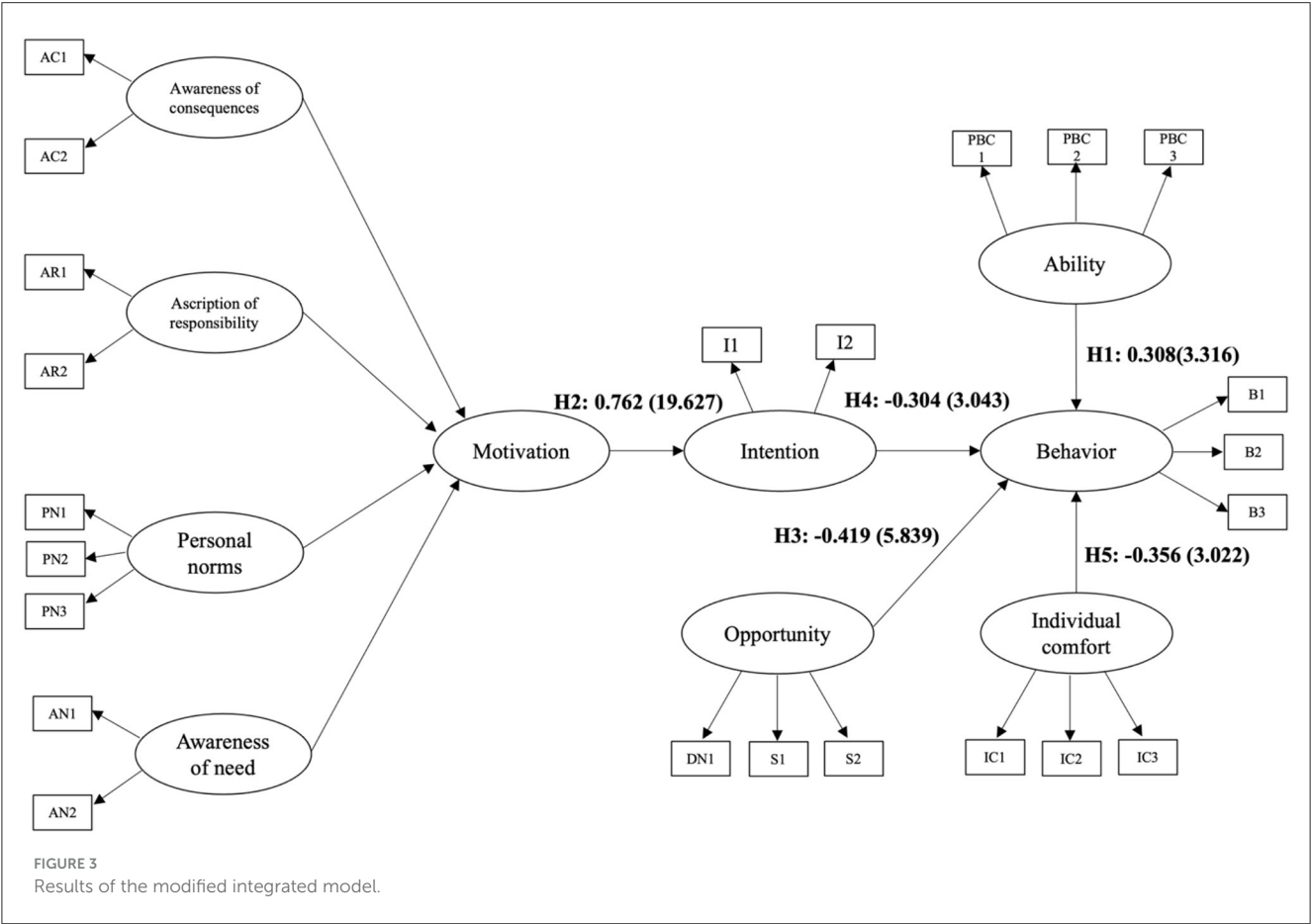
5 Discussion and implications

5.1 Interpreting the unexpected negative effects

The findings of this study reveal several unexpected relationships, particularly the negative effects of opportunity, intention, and individual comfort on energy-saving behavior. First, the negative effect of opportunity on energy-saving behavior suggests that workplace structures and organizational norms may not always facilitate conservation actions. Previous studies have generally assumed that the presence of energy-saving policies and workplace support leads to higher engagement in sustainable practices. However, our findings align with behavioral resistance theories, which suggest that when individuals perceive environmental policies as externally imposed rather than self-directed, they may actively disengage from the desired behavior. Office workers might view certain conservation initiatives as inconvenient or misaligned with their work habits, leading to psychological reactance, where individuals resist changes that limit their autonomy. Second, the negative relationship

TABLE 4 Discriminant validity (HTMT).

	Ability	Energy-saving behavior	Individual comfort	Intention	Motivation	Opportunity
Ability	–	–	–	–	–	–
Energy-saving behavior	0.804	–	–	–	–	–
Individual comfort	0.848	0.850	–	–	–	–
Intention	0.791	0.321	0.764	–	–	–
Motivation	0.766	0.471	0.779	0.794	–	–
Opportunity	0.617	0.730	0.691	0.609	0.425	–



between intention and energy-saving behavior highlights the well-documented intention-behavior gap, wherein stated intentions do not always translate into actual actions. Several possible explanations exist for this discrepancy. Office workers may express willingness to save energy, but situational constraints such as high workload demands, ingrained workplace habits, or a lack of direct incentives could prevent them from acting accordingly. Moreover, workplace energy-saving behaviors often rely on social reinforcement, meaning that without visible peer engagement or direct accountability, office workers may deprioritize conservation efforts despite their stated intentions. Finally, the negative association between individual comfort and energy-saving behavior suggests that Office workers prioritize thermal and lighting comfort over sustainability. Unlike household energy-saving decisions, where individuals directly benefit from

lower energy costs, workplace environments often detach personal benefits from conservation behaviors. Office workers may feel that reducing air conditioning or adjusting lighting levels has little direct impact on their well-being but could compromise their comfort, productivity, or job satisfaction. This aligns with findings from adaptive thermal comfort models, which emphasize that personal comfort often overrides sustainability concerns in decision-making.

5.2 Theoretical contributions

This study advances the literature on workplace energy conservation by providing new insights into the complex

TABLE 5 Effect size (f^2).

	Ability	Energy-saving behavior	Individual's comfort	Intention	Motivation	Opportunity
Ability		1.02				
Energy-saving behavior						
Individual's comfort		0.226				
Intention		0.46		0.582		
Motivation						
Opportunity		0.444				

TABLE 6 Results of path analysis and hypotheses test.

	Path coefficients	STDEV	T-statistics	P-values	Support
Ability > Energy-saving behavior	0.308	0.093	3.316	0.001	Yes
Motivation > Intention	0.762	0.039	19.627	0.000	Yes
Opportunity > Energy-saving behavior	−0.419	0.072	5.839	0.000	Yes
Intention > Energy-saving behavior	−0.304	0.100	3.043	0.002	Yes
Individual's comfort > Energy-saving behavior	−0.356	0.118	3.022	0.003	Yes

relationships among motivation, opportunity, ability, intention, and individual comfort in shaping energy-saving behavior. While previous research often assumes that opportunity, intention, and comfort facilitate conservation efforts, the findings suggest that their effects are more nuanced and context-dependent. In contrast, the results confirm the positive roles of ability and motivation, reinforcing the importance of perceived behavioral control and intrinsic drivers in sustainability models. The negative effect of opportunity on energy-saving behavior challenges a key assumption of the Motivation-Opportunity-Ability (MOA) model, which traditionally views opportunity as an enabler. These findings indicate that when workplace energy-saving policies are perceived as externally imposed rather than empowering, they may induce psychological resistance, reducing engagement. This perspective aligns with behavioral resistance theories, which emphasize that rigid policies can sometimes act as constraints rather than facilitators. Such insights refine the understanding of how structural and social influences shape workplace sustainability behavior. Another key finding highlights the disconnect between intention and behavior, reinforcing the intention-behavior gap discussed in the Theory of Planned Behavior (TPB). Although TPB assumes that strong intentions predict behavior, the results suggest that external workplace constraints, such as workload pressures or the absence of visible reinforcement, can weaken this relationship. This challenges the assumption that intention alone is a sufficient predictor of energy conservation, particularly in structured organizational environments. Moreover, the study contributes to adaptive thermal comfort research by demonstrating that individual comfort preferences may sometimes conflict with sustainability efforts. Unlike prior models that assume individuals adjust their behaviors to environmental conditions, the results indicate that office workers may prioritize personal comfort over energy efficiency, particularly when energy-saving measures require significant trade-offs. This perspective refines current

energy-saving behavior models by incorporating the role of workplace comfort as a potential barrier to conservation efforts.

Despite these unexpected negative effects, the findings confirm the strong positive impact of ability and motivation on energy-saving behavior. Office workers who possess a greater sense of control and confidence in their ability to conserve energy are more likely to engage in sustainable actions. Likewise, individuals with higher intrinsic motivation, driven by personal norms, moral responsibility, and awareness of consequences, demonstrate stronger energy-saving intentions. These findings reinforce the role of perceived behavioral control within TPB and highlight the critical role of intrinsic motivation in pro-environmental workplace behaviors. By integrating MOA, NAM, and TPB, this study extends theoretical models by demonstrating how psychological, organizational, and contextual factors interact to shape workplace energy-saving behaviors. Furthermore, the results challenge overly simplistic assumptions regarding opportunity, intention, and comfort, offering a more nuanced understanding of workplace energy conservation. These insights contribute to the refinement of behavioral theories and support the development of more context-sensitive models for understanding sustainability in organizational settings.

5.3 Practical implications

The findings of this study offer actionable insights for promoting energy-saving behaviors in workplace environments, particularly within the Thai context. These implications address organizational practices and broader policy initiatives, ensuring that interventions align with cultural and environmental factors. One key practical implication is the need to foster energy-saving cultures within organizations. This study demonstrates that moral responsibility and collective accountability are pivotal in

shaping office workers' behaviors. Programs that leverage peer influence and management-led initiatives can align individual actions with organizational sustainability goals. For example, Su et al. (2022) found that cultivating an energy-conscious workplace culture enhances behavioral engagement, a finding supported by the strong role of motivation in this study. The research also underscores the importance of addressing structural barriers to energy-saving behaviors. The negative relationship between opportunity and energy-saving behaviors highlights challenges such as inadequate resources, unclear policies, and lack of organizational support. Providing accessible energy-efficient technologies, clear operational guidelines, and training programs can mitigate these barriers, enabling workers to adopt sustainable practices more effectively (Chen and Chen, 2021). Balancing thermal comfort and conservation goals emerges as another critical area for intervention. Findings from this study indicate that individual comfort significantly influences energy-saving behaviors, suggesting that rigid energy-saving measures may face resistance. Flexible and adaptive thermal control systems and office workers' feedback mechanisms can help organizations balance comfort and conservation without undermining productivity (Iamtrakul et al., 2020). Finally, regional considerations specific to Thailand, such as the prevalence of urban heat islands and the increasing adoption of hybrid work models, should inform energy-saving strategies. Tailored interventions that address these contextual factors, such as optimizing energy use during peak hours or integrating hybrid-friendly policies, can enhance the effectiveness of workplace sustainability initiatives (Mantesi et al., 2022; Hnin et al., 2024). These practical recommendations provide a roadmap for organizations and policymakers to design effective energy-saving interventions that are both culturally relevant and operationally feasible. By addressing the interplay of motivation, opportunity, and ability within specific workplace contexts, this research offers a comprehensive approach to achieving sustainable energy management.

5.4 Limitations and future research

While this study provides important insights, several limitations should be acknowledged. The sample size ($n = 105$) limits the generalizability of the findings, particularly regarding the unexpected negative relationships. Future research should employ larger, more diverse samples across different industries and cultural contexts to validate these results. Moreover, the study's cross-sectional design does not capture long-term behavioral changes. Longitudinal studies are needed to examine whether workplace energy-saving behaviors evolve, particularly as organizational cultures shift and policies adapt. While this study focuses on behavioral predictors, future research could explore the role of emerging technologies, such as AI-driven energy management systems, workplace automation, and digital nudges, in shaping conservation behaviors. Integrating behavioral insights with smart technology solutions could provide more effective, scalable interventions for workplace sustainability. By addressing these

limitations, future research can build on the insights provided by this study, refining the framework for broader applicability and impact.

6 Conclusion

This study contributes to the growing body of research on workplace energy conservation by examining how motivation, opportunity, ability, intention, and individual comfort influence energy-saving behavior. Using an integrated framework that combines the Motivation-Opportunity-Ability (MOA) model, the Norm Activation Model (NAM), and the Theory of Planned Behavior (TPB), the study provides insights into the complex factors shaping energy-saving behaviors in office environments in Thailand. The findings confirm that motivation and ability positively influence energy-saving behavior, highlighting the importance of intrinsic drivers (personal norms and awareness of consequences) and perceived control in shaping conservation actions. However, opportunity, intention, and individual comfort exhibited unexpected negative relationships with energy-saving behavior. Rather than dismissing these results as purely statistical anomalies, this study suggests that organizational constraints, psychological resistance, and thermal comfort trade-offs may explain why workplace conservation efforts do not always lead to expected behavioral changes. From a theoretical perspective, these findings challenge simplistic assumptions in behavioral models that assume external enablers (opportunity) and self-reported intentions always lead to pro-environmental actions. Instead, the study highlights the need to consider policy perception effects, social norm reinforcement, and behavioral inertia in understanding workplace energy-saving behaviors. The integration of adaptive comfort models and behavioral resistance theories provides a more nuanced framework for future sustainability research. From a practical standpoint, the study underscores the need for organizations to rethink energy-saving interventions. Effective policies should not only provide resources and structural support but also address office workers' autonomy, real-time behavioral feedback, and workplace comfort needs. The study suggests that participatory policy design, digital energy monitoring tools, and incentive-driven conservation programs could help bridge the gap between intention and action. Despite its contributions, this study has several limitations. The sample size ($n = 105$), while appropriate for PLS-SEM analysis, remains relatively small, which may have amplified suppressor effects. Future research should validate these findings with larger, cross-industry samples to improve generalizability. Additionally, this study employed a cross-sectional design, limiting insights into long-term behavioral shifts. Longitudinal research could assess how energy-saving behaviors evolve over time and whether policy adjustments lead to sustained engagement. Another avenue for future research is exploring the role of emerging technologies in workplace energy conservation. With advancements in AI-driven energy management systems, behavioral nudging via smart office solutions, and gamification-based sustainability programs, future studies could examine how digital interventions influence conservation 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 author.

Ethics statement

Ethical approval was not required for the studies involving humans because the study did not require ethical approval as it involved administering an online survey to examine workers' energy-saving behavior. The survey did not request any personally identifiable information from participants, thereby eliminating the necessity for ethical clearance. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants.

Author contributions

SH: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. AJ: Writing – review & editing. JK: Data curation, Investigation, Writing – review & editing. CJ: Supervision, Writing – review & editing. YK: Supervision, Writing – review & editing.

References

- Akhound, A., Rizvi, A. M., Ahmed, W., and Khan, M. N. (2022). Understanding intentions to reduce energy consumption at the workplace by employees: case of a developing country. *Manage. Environ. Q. Int. J.* 33, 166–184. doi: 10.1108/MEQ-03-2021-0048
- Apipuchayakul, N., and Vassanadumrongdee, S. (2020). Factors affecting the consumption of energy-efficient lighting products: exploring purchase behaviors of Thai consumers. *Sustainability* 12:4887. doi: 10.3390/su12124887
- Bian, W., and Hu, W. (2024). Optimising dimming systems for visual experience and energy consumption using genetic algorithms and neural networks. *Energy Build.* 329:115227. doi: 10.1016/j.enbuild.2024.115227
- Carrico, A. R., and Riemer, M. (2011). Motivating energy conservation in the workplace: an evaluation of the use of group-level feedback and peer education. *J. Environ. Psychol.* 31, 1–13. doi: 10.1016/j.jenvp.2010.11.004
- Carrus, G., Tiberio, L., Mastandrea, S., Chokrai, P., Fritsche, I., Klöckner, C. A., et al. (2021). Psychological predictors of energy saving behavior: a meta-analytic approach. *Front. Psychol.* 12:648221.
- Chai, K.-H., and Baudelaire, C. (2015). Understanding the energy efficiency gap in Singapore: a motivation, opportunity, and ability perspective. *J. Clean. Prod.* 100, 224–234. doi: 10.1016/j.jclepro.2015.03.064
- Chen, C., and Knight, K. (2014). Energy at work: social psychological factors affecting energy conservation intentions within Chinese electric power companies. *Energy Res. Soc. Sci.* 4, 23–31. doi: 10.1016/j.erss.2014.08.004
- Chen, C.-H. V., and Chen, Y.-C. (2021). Assessment of enhancing employee engagement in energy-saving behavior at workplace: an empirical study. *Sustainability* 13:2457. doi: 10.3390/su13052457
- Conner, M., Kirk, S. F. L., Cade, J. E., and Barrett, J. H. (2003). Environmental influences: factors influencing a woman's decision to use dietary supplements. *J. Nutr.* 133, 1978S–1982S. doi: 10.1093/jn/133.6.1978S
- Deci, E. L., and Ryan, R. M. (2000). The “what” and “why” of goal pursuits: human needs and the self-determination of behavior. *Psychol. Inq.* 11, 227–268. doi: 10.1207/S15327965PLI1104_01
- Donovan, J. D., Masli, E. K., Topple, C., Ike, M., Borgert, T., Vanichseni, T., et al. (2016). “Sustainability practices in Thailand,” in *Corporate Sustainability Assessments* (Routledge), 67–87.
- Fornara, F., Pattitoni, P., Mura, M., and Strazzera, E. (2016). Predicting intention to improve household energy efficiency: the role of value-belief-norm theory, normative and informational influence, and specific attitude. *J. Environ. Psychol.* 45, 1–10. doi: 10.1016/j.jenvp.2015.11.001
- Forward, S. E. (2009). The theory of planned behaviour: The role of descriptive norms and past behaviour in the prediction of drivers' intentions to violate. *Transport. Res. Part F: Traff. Psychol. Behav.* 12, 198–207. doi: 10.1016/j.trf.2008.12.002
- Hnin, S. W., Javed, A., and Karnjana, J. (2024). Sustainable energy practices in Thailand and Japan: a comparative analysis. *Sustainability* 16:6877. doi: 10.3390/su16166877
- Iamtrakul, P., Chaypong, S., and Klaylee, J. (2020). Measuring the behavior and preference for energy-saving and household carbon emission reduction of urban residents in Bangkok and its vicinities, Thailand. *Lowland Technol. Int.* 22, 239–248. doi: 10.1088/1755-1315/897/1/012023
- Jareemit, D., and Limmeechokchai, B. (2019). Impact of homeowner's behaviors on residential energy consumption in Bangkok, Thailand. *J. Build. Eng.* 21, 328–335. doi: 10.1016/j.jobe.2018.10.030
- Kim, Y. G., Woo, E., and Nam, J. (2018). Sharing economy perspective on an integrative framework of the NAM and TPB. *Int. J. Hosp. Manage.* 72, 109–117. doi: 10.1016/j.ijhm.2018.01.008
- Kotsopoulos, D., Bardaki, C., Lounis, S., and Pramataris, K. (2018). Employee profiles and preferences towards IoT-enabled gamification for energy conservation. *Int. J. Serious Games* 5, 65–85.
- Li, D., Xu, X., Chen, C., and Menassa, C. (2019). Understanding energy-saving behaviors in the American workplace: A unified theory of motivation, opportunity, and ability. *Energy Res. Soc. Sci.* 51, 198–209. doi: 10.1016/j.erss.2019.01.020
- Lopes, J. R. N., de Araújo Kalid, R., Rodriguez, J. L. M., and Ávila Filho, S. (2019). A new model for assessing industrial worker behavior regarding energy saving

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was supported by the Japan Advanced Institute of Science and Technology (JAIST) and the National Science and Technology Development Agency (NSTDA). This research was also supported by the Center of Excellence in Logistics and Supply Chain Systems Engineering and Technology (COE LogEn), Sirindhorn International Institute of Technology, Thammasat University.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

considering the theory of planned behavior, norm activation model, and human reliability. *Resour. Conserv. Recycl.* 145, 268–278. doi: 10.1016/j.resconrec.2019.02.042

MacCallum, R. C., and Browne, M. W. (1993). The use of causal indicators in covariance structure models: some practical issues. *Psychol. Bull.* 114, 533. doi: 10.1037/0033-2909.114.3.533

Mantesi, E., Chmutina, K., and Goodier, C. (2022). The office of the future: operational energy consumption in the post-pandemic era. *Energy Res. Soc. Sci.* 87:102472. doi: 10.1016/j.erss.2021.102472

Michie, S., van Stralen, M. M., and West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement. Sci.* 6:42. doi: 10.1186/1748-5908-6-42

Shi, H., Fan, J., and Zhao, D. (2017). Predicting household PM2.5-reduction behavior in Chinese urban areas: an integrative model of the theory of planned behavior and norm activation theory. *J. Clean. Prod.* 145, 64–73. doi: 10.1016/j.jclepro.2016.12.169

Shrestha, B., Tiwari, S. R., Bajracharya, S. B., Keitsch, M. M., and Rijal, H. B. (2021). Review on the importance of gender perspective in household energy-saving behavior and energy transition for sustainability. *Energies* 14:7571. doi: 10.3390/en14227571

Su, S., Li, J., Yuan, J., Tang, M., Wang, E., Ding, Y., et al. (2022). How can energy-saving culture of a company influence energy behaviors and consumptions

in its offices? A simulation and optimization model. *J. Build. Eng.* 58:105011. doi: 10.1016/j.jobe.2022.105011

Tverskoi, D., Xu, X., Nelson, H., and Menassa, C. (2021). Energy saving at work: understanding the roles of normative values and perceived benefits and costs in single-person and shared offices in the United States. *Energy Res. Soc. Sci.* 74:101982. doi: 10.1016/j.erss.2021.102173

Wang, B., Wang, X., Guo, D., Zhang, B., and Wang, Z. (2018). Analysis of factors influencing residents' habitual energy-saving behaviour based on NAM and TPB models: egoism or altruism? *Energy Policy* 116, 68–77. doi: 10.1016/j.enpol.2018.01.055

Weerasinghe, A. S., Rotimi, J. O. B., and Rasheed, E. O. (2023). Modelling of underlying social psychological effects on occupant energy-related behaviours. *Build. Environ.* 231:110055 doi: 10.1016/j.buildenv.2023.110055

Wong, K. K. K. (2013). Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. *Market. Bull.* 24, 1–32.

Xu, X., Chen, C. F., Li, D., and Menassa, C. (2020). Energy saving at work: exploring the role of social norms, perceived control, and ascribed responsibility in different office layouts. *Front. Built Environ.* 6:16. doi: 10.3389/fbuil.2020.00016

Zhang, Y., Fu, B., Maani, S., and Wen, L. (2024). Employee energy-saving behaviors: Review of theories, influencing factors, and interventions. *Renew. Sustain. Energy Rev.* 203:114766 doi: 10.1016/j.rser.2024.114766



OPEN ACCESS

EDITED BY

Christian Andreas Klöckner,
Norwegian University of Science and
Technology, Norway

REVIEWED BY

Giuseppe Carrus,
Roma Tre University, Italy
Annika Thies,
Johann Heinrich von Thünen Institute,
Germany

*CORRESPONDENCE

Sari R. R. Nijssen
✉ sari.nijssen@univie.ac.at

RECEIVED 28 May 2024

ACCEPTED 27 March 2025

PUBLISHED 30 April 2025

CITATION

Ardesch TF, Klaperski-van der Wal S,
Nijssen SRR and Müller BCN (2025) Reducing
meat consumption through default nudging:
a field study.
Front. Psychol. 16:1439641.
doi: 10.3389/fpsyg.2025.1439641

COPYRIGHT

© 2025 Ardesch, Klaperski-van der Wal,
Nijssen and Müller. This is an open-access
article distributed under the terms of the
[Creative Commons Attribution License](#)
(CC BY). The use, distribution or reproduction
in other forums is permitted, provided the
original author(s) and the copyright owner(s)
are credited and that the original publication
in this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Reducing meat consumption through default nudging: a field study

Tamar F. Ardesch¹, Sandra Klaperski-van der Wal¹,
Sari R. R. Nijssen^{2*} and Barbara C. N. Müller¹

¹Behavioural Science Institute, Radboud University Nijmegen, Nijmegen, Netherlands, ²Department of Emotion, Cognition, and Methods in Psychology, Urban and Environmental Psychology Group, Faculty of Psychology, University of Vienna, Vienna, Austria

Meat consumption negatively impacts ecological sustainability, health, and animal welfare. Research suggested promising effects of re-designing product arrangements so that vegetarian items become the default. However, whether default nudging leads to actual behaviour change in the context of meat consumption, and whether these effects are sustainable on the long-term remains unknown. Therefore, this field experiment investigated (a) the effect of vegetarian default nudging on food choices in a real-life setting, and (b) potential long-term associations between vegetarian defaults, food choices, and psychological resistance (i.e., reactance and inertia). A vegetarian default intervention was applied in a university cafeteria. Behavioural data (cafeteria sales data regarding meat and vegetarian purchases; $N = 4,099$) was collected before (T0; baseline), right after implementation (T1), and 10 weeks after implementation of the intervention (T2). Additionally, survey data was collected at T1 and T2 to assess potential psychological side-effects, such as resistance to the intervention. Results indicate that vegetarian default nudging was highly effective at changing food choices, with more than twice the number of vegetarian items sold relative to baseline. Moreover, in the default nudging condition, the number of meat items decreased to less than a third of the baseline measurement. At the same time, the survey data revealed no psychological side-effect of the intervention on reactance or inertia. This was stable over time. Our research offers empirical support for the effectiveness of a non-coercive strategy to change consumer behaviour towards more sustainable, animal friendly, and healthier food choices.

KEYWORDS

default nudging, intervention research, meat consumption, environmental impact, behaviour change

Introduction

Reducing meat consumption through default nudging: a field study

Global meat consumption nearly doubled in the last 20 years (Parlasca and Qaim, 2022). This increase comes at the cost of human health (e.g., zoonosis, cancers, cardiovascular diseases and antibiotic-resistant pathogens; Almashhadany, 2021; Godfray et al., 2018; González et al., 2020; Monger et al., 2021), the environment (i.e., significant resource demands and emissions; González et al., 2020; Lehner et al., 2016; Machovina et al., 2015) and animal welfare (i.e., unhygienic and constrained living conditions; Appleby et al., 2004; Fiber-Ostrow and Lovell, 2016; and the abuse and slaughter of animals; Eisnitz, 2009; Roser, 2023). Although

many individuals are interested in reducing their meat consumption, accomplishing a complete absence of eating meat appears to be difficult: while 31% of the population in the European Union indicate to be willing to reduce their meat intake, 13% indicate to avoid meat completely (Eurobarometer, 2023; EPRS, 2020). Importantly, default nudging is a well-established behavioural intervention strategy particularly relevant for deeply entrenched habits—such as meat consumption (Meier et al., 2022). Therefore, the goal of the current study was to investigate whether a default nudging intervention could be effective at changing food choices. Specifically, we tested this in a field setting, with measurements of real behaviour (i.e., sales data) and surveys to investigate how behavioural choices relate to potential psychological side-effects such as resistance. Moreover, to assess the potential long-term effects of default vegetarian nudging, data was collected at three time points across a period of 4 months.

The intention-behaviour gap and default nudging

The intention-behaviour gap has been observed in a wide variety of health-related and sustainable behaviours (Blake, 1999; Carrington et al., 2014; Fishbein and Ajzen, 1977; Knowles and Linn, 2004), such as exercise (Rhodes and de Bruijn, 2013), organ donation (Crawshaw et al., 2022), electronic waste recycling (Echegaray and Hansstein, 2017), and sustainable fashion (Park and Lin, 2020). Of particular relevance to the current study, research has also identified an intention-behaviour gap specifically in the context of meat consumption. For example, research by Arnaudova et al. (2022) as well as Laffan et al. (2023) shows that, respectively, half and one-third of participants in their studies failed to align their intention to reduce their meat intake with actual dietary choices, with taste and cooking habits being ultimately more important determinants for eating behaviour (Laffan et al., 2023).

A specific behavioural intervention which can be used to reduce meat consumption among individuals who encounter difficulties aligning their intentions and behaviour, is vegetarian default nudging (Campbell-Arvai et al., 2014; De Vaan et al., 2019). A systematic review of twelve articles indeed suggests that default nudging is an encouraging intervention method to decrease meat consumption (Meier et al., 2022). This default nudging is a cost-effective and non-disruptive strategy that changes behaviour through subtle environmental adjustments to increase the chance for the desired behaviour, while preserving individuals' freedom of choice (Campbell-Arvai et al., 2014; Hertwig and Grüne-Yanoff, 2017; Kollmuss and Agyeman, 2002; Papies, 2017; Thaler and Sunstein, 2008). A default option is the standard option provided when individuals do not explicitly request alternatives (Thaler and Sunstein, 2008). Other options (e.g., meat items) are thus available, but they require proactive action from the individual. This makes vegetarian defaults an effective strategy for attempting to change the behaviour of individuals who are opposed to changing their food habits as well. As humans generally prefer convenience (Farquhar and Rowley, 2009), it could be that opting for the behaviour requiring the least effort (i.e., choosing the vegetarian default option) outweighs the desire for an initially intended but more demanding option (i.e., proactively inquiring about a meat or fish item) even in individuals who are initially opposed to

such changes. This was demonstrated in a study by Hielkema et al. (2022), in which the vegetarian default enhanced the choice for the vegetarian option more strongly among individuals with no intention to reduce their meat intake than among those who already aimed at reducing their meat consumption. Additionally, since the desired behaviour is not forced, there is less chance of non-compliance (Knowles and Linn, 2004) or backlash effects (i.e., increasing meat consumption as a reaction to feared or possible meat restrictions; Lombardini and Lankoski, 2013). Thus, freedom of choice is preserved using vegetarian defaults, whilst the chances of seeking the less desired alternative option decrease (Hertwig and Grüne-Yanoff, 2017).

Whilst transitioning to entirely plant-based defaults would offer the greatest benefits in terms of ecological sustainability, health, and animal welfare (Fehér et al., 2020; Willett et al., 2019), it may be considered too radical by the population consuming animal-derived products, as vegan or plant-based diets are often even more controversial than vegetarian diets (e.g., De Groeve and Rosenfeld, 2022; Gregson et al., 2022; MacInnis and Hodson, 2017). As previous research has shown (e.g., Betz et al., 2022; Campbell-Arvai et al., 2014; De Vaan et al., 2019; Gravert and Kurz, 2021; Meier et al., 2022; Taufik et al., 2022), presenting a vegetarian option as the default can increase both the selection of meat-free dishes and the demand for vegetarian options when people eat out of home. Therefore, changing the default food items into vegetarian food items, seems currently a more realistic approach for increasing the demand for vegetarian dishes and reducing the demand for meat and fish dishes, without demanding a too substantial or controversial shift.

The current study

Recent studies investigating vegetarian defaults in either US or European contexts were conducted solely in online and laboratory settings and were not longitudinal (e.g., De Vaan et al., 2019). Furthermore, studies that used a more naturalistic set-up kept certain unnaturalistic constraints in their design. For instance, the study by Campbell-Arvai et al. (2014) was conducted in dining halls of universities, but the set-up lacked the real-life consequences of their choice, that is, paying and receiving the food. In contrast, the field study lasting for four weeks by Taufik et al. (2022) did include the real-life consequences but used the vegetarian default solely on the week menu, leaving the regular menu unchanged, with meat and fish options available. Furthermore, the field study by Gravert and Kurz (2021) solely examined a menu with two options available (i.e., meat and fish vs. vegetarian and fish), with the footnote that, on request, a vegetarian or meat dish could be prepared. In sum, the existing evidence is limited with regard to the internal and external validity, as well as the generalizability of their results. Methodological improvements, such as longitudinal data collection and a more realistic range of menu options, are needed to draw effective conclusions about the impact of vegetarian default nudging on food choice.

We address the shortcomings and add to earlier studies, as our study tests a default nudge in a field setting, with measurements of real behaviour (i.e., sales data) and survey data to investigate how behavioural choices relate to potential psychological side-effects such as resistance. Moreover, to assess the potential long-term effects of default vegetarian nudging, data was collected at three time points

across a period of 4 months. We, thus, aim to increase internal and external validity, as well as the generalizability, which might contribute to clarify how vegetarian defaults can be implemented as a subtle, non-disruptive, and cost-efficient, yet effective and feasible behaviour change strategy.

The current study set out to investigate the role of vegetarian defaults on meat consumption on the short- and long-term. We conducted a longitudinal field study in a university cafeteria over a period of 16 weeks, assessing actual behavioural choices. At three timepoints, sales data for vegetarian and non-vegetarian items (i.e., behavioural data) were collected to monitor behavioural changes. With regard to the behavioural data and building upon prior research (Campbell-Arvai et al., 2014; De Vaan et al., 2019; Gravert and Kurz, 2021; Hielkema et al., 2022; Meier et al., 2022; Taufik et al., 2022), we hypothesized that changing the default items into solely vegetarian items would be associated with an increase in the sales of vegetarian items, alongside a decline in the sales of fish and meat items (H1a). Furthermore, we expected this pattern to remain stable over time at the follow-up measure (H1b).

In addition to these central hypotheses, we were also interested in exploring two potential psychological side-effects of a default nudging intervention. First, an often-noted potential negative side-effect of default nudging is reactance – which seems pertinent particularly in the domain of food choices and was therefore included in the survey (e.g., Rosenberg and Siegel, 2018; Van Dinther, 2015). Second, a potential positive side-effect might occur for customers who experience inertia regarding their meat consumption. For them, our default intervention might act as nudge towards a behavioural choice that they consciously support already, but find difficult to achieve (Joyner-Grantham et al., 2009; Knowles and Linn, 2004; Polites and Karahanna, 2012). All hypotheses and research questions were preregistered on the Open Science Framework.¹

Method

This study was conducted at the central cafeteria of the Faculty of Social Sciences ‘De Iris.’ Ethical approval from the Ethics Committee of Radboud University Nijmegen was obtained before data collection: ECS-LT-2022-10-12-11646. The analyses and materials are available on the Open Science Framework (see text footnote 1).

Participants

Behavioural data

For the behavioural data, the cafeteria provided count data on the items sold during lunch breaks, specifying whether items were non-vegetarian (meat and/or fish) or vegetarian (including vegan) items. More precisely, the behavioural data consisted of three lists detailing the total quantities sold of each item over the periods of 2 weeks. Meat/fish items had approximately the same price as vegetarian/vegan items. Snacks (e.g., candy bars and fruits) and breakfast items (e.g., yoghurt or croissants) were not included in the

list. Furthermore, due to practical constraints, it was not feasible to obtain a list with all the separate transactions, specifying the number and sort of items sold within each purchase. Thus, it is important to note that it is unclear whether one customer purchased solely one or multiple items. Whilst this data collection process involved human participants, no personal identifying information was gathered, hence informed consent was not obtained for assessing behavioural data. Each datapoint represents one food item that was sold in the between 11:45 and 13:30 during one of the three data collection periods. In total, there were 4,099 items sold, with 1,245 items sold at T0, 1,493 items at T1, and 1,361 items at T2. A post-hoc sensitivity analysis revealed that, at $\alpha = 0.05$, power = 0.95, and the degrees of freedom set to 2, the minimum test statistic detectable by this research design and sample size would be $\chi^2 = 5.99$.

Survey data

The initial sample that participated in the survey consisted of $N = 314$ customers. $N = 87$ participants (27.71%) had incomplete data on the relevant variables due to a technical error (i.e., the items assessing reactance, inertia, and covariates) and were therefore excluded from further analysis. This resulted in a final sample of $N = 227$ participants (191 women, 29 men, 3 non-binary, and 4 of unknown gender) between 18 and 37 years old ($M_{age} = 20.71$, $SD_{age} = 2.58$). The sample size was determined based on an effect size of $f^2 = 0.15$ (medium effect size; Campbell-Arvai et al., 2014), requiring a sample size of at least 66 participants per time point (i.e., a total of at least 198 participants) to achieve a statistical power of 95%.

Participants were recruited in the cafeteria. Eligible participants had to be regular customers of the cafeteria (i.e., purchase meals at least once a month). Participants were permitted to participate only once per timepoint to ensure statistical independence of the data points. Participants were self-selected and received a snack (i.e., a chocolate bar or candy) for their participation. The completion of the survey lasted approximately 5 min. Furthermore, participants could submit their email address to participate in a lottery to win a 50€ voucher.

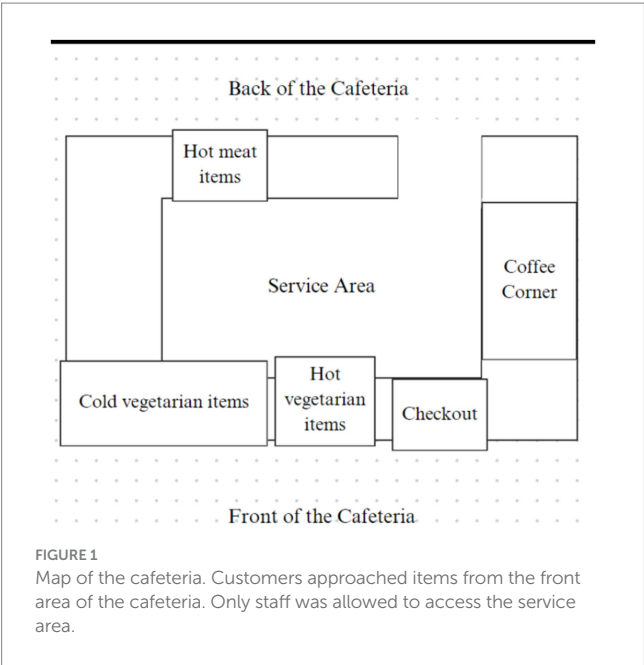
Procedure

This field study applied a default nudge intervention. To create the vegetarian default, the displayed food items in the cafeteria’s showcase (i.e., the defaults) were changed to exclusively feature vegetarian items. Fish and meat items remained available but were listed on screens above the counter and had to be specifically requested; they were no longer displayed in the showcase (see OSF for the list of the available food items per timepoint). Due to practical constraints, warm snacks containing meat were placed in the back of the cafeteria instead of under the counter (see Figure 1). Thus, these were not completely out of sight, but the warm vegetarian snacks were more visible as they were displayed in front of the customers on top of the front counter. Data were collected during lunch breaks from 11:45 to 13:30 for 2 weeks per timepoint. Data collection occurred at three different timepoints (see Figure 2): the baseline measure, 6 weeks before the intervention (T0); the post-measure, immediately after the start of the intervention (T1); and the follow-up measure, 10 weeks after the default intervention was introduced (T2).

¹ <https://osf.io/6fsbj/>.

These periods were selected while considering holidays and exam weeks to ensure an accurate representation of the entire year in terms of visitors and sales.

In addition to the behavioural data, visitors of the cafeteria were invited to participate in a survey. If eligible, they scanned a QR-code presented by the researcher and were directed to the online survey (Qualtrics, 2023), gave informed consent, and were informed about the study goal. After survey completion, participants were thanked, debriefed, and rewarded. Due to practical constraints, it was not feasible to directly invite customers of the cafeteria after purchase, as this would have disrupted the workflow of the cafeteria. Thus, it is important to note that the sales data and the survey data are not connected, that is, the participants who filled out the survey were not necessarily the ones purchasing food items during the measurement period.



Materials

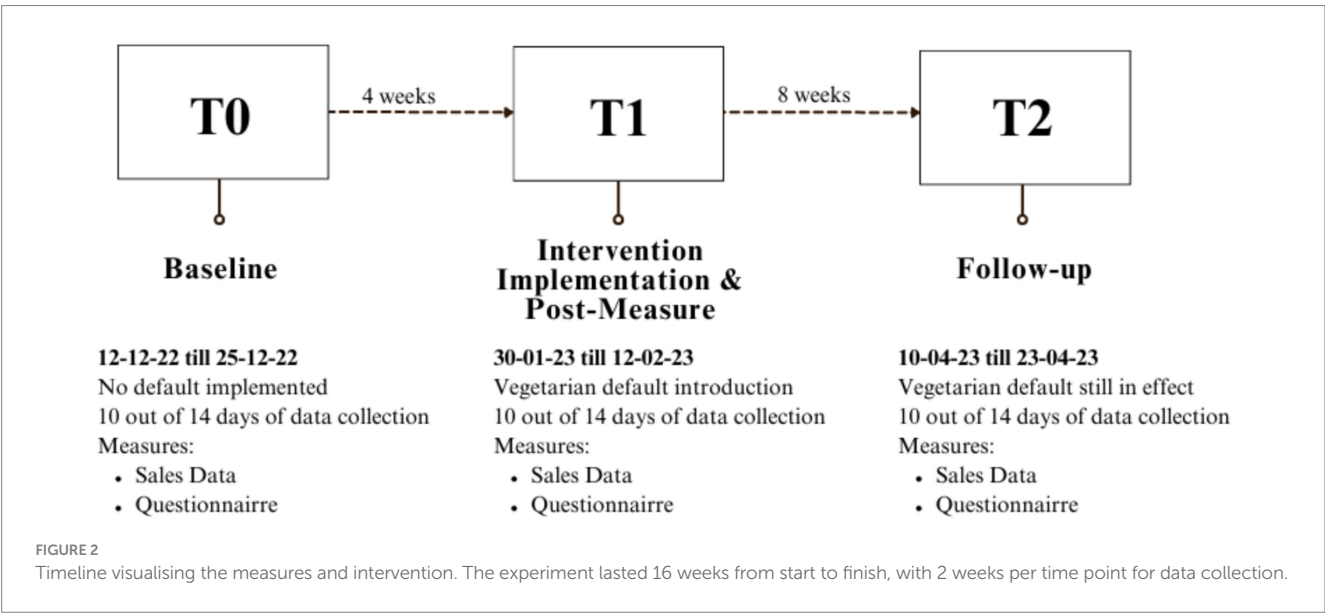
Survey

Dietary Preferences. The survey² was phrased in English and contained a semi-closed-ended question on whether respondents followed a certain diet (Kloosterman et al., 2021) to check if the distribution of the diets were equal across the three different measures.

Reactance. Reactance was assessed with two scales: perceived threat of freedom and anger (Dillard and Shen, 2005). The items were adapted from the original scales in two significant ways. First, we used the phrase “the food options visible in the counter” for each item (e.g., “The food options visible in the counter threatened my freedom of choice”). Second, we phrased each item twice: once to assess the general perceived threat to freedom and anger regarding the selection of food options, and once to assess the perceived threat to freedom and anger as regarding the board of the cafeteria and its decision-making regarding the food options (e.g., “By offering certain food options, the board of the cafeteria threatened my freedom of choice”). These modifications resulted in a total of eight items per scale, resulting in a total of 16 items measuring reactance. Participants could respond on a 5-point Likert scale (1 = totally disagree, 5 = totally agree). Reliability measures indicated acceptable reliability (Cronbach’s $\alpha = 0.73$) for the threat of freedom scale and an excellent reliability for the anger scale (Cronbach’s $\alpha = 0.90$) related to questions about food options. Meanwhile, questions related to the cafeteria board showed good reliability for the threat of freedom scale (Cronbach’s $\alpha = 0.81$) and excellent reliability for the anger scale (Cronbach’s $\alpha = 0.92$).

Inertia. Inertia was assessed using six items (Cronbach’s $\alpha = 0.90$), based on Han et al. (2011). For example: “I think increasing the

2 The survey also contained several items regarding the cafeteria’s pricing, variety, reasons for purchasing food items, as well as respondents’ own dietary restrictions. These data were solely collected for collaboration with the cafeteria and, consequently, were not analysed further.



number of vegetarian meals I consume would be better, but I fail to do so." Participants responded on a 5-point Likert scale (1 = totally disagree, 5 = totally agree).

Demographic Information & Covariates. Participants provided their age numerically and indicated their gender with answer options "Male," "Female," "Other . . .," and "Prefer not to say." In addition, eight other potential covariates were measured and analysed. Since these analyses were of a more exploratory nature, and none provided significant or otherwise relevant insight into the psychological dimensions of our study, we decided to omit them from the main text of this manuscript for the sake of conciseness. However, we included a full overview of the covariates and the relevant analyses on the Open Science Framework.

Data analysis

The data were analysed using the statistical software [R Core Team \(2023\)](#) and [JASP Team \(2023\)](#).

Principal component analyses

Initially, several Principal Component Analyses were conducted with [JASP Team \(2023\)](#) to examine item relationships. The first analysis explored the relation between the eight items of the reactance anger scale and the eight items of the threat of freedom scale. The results indicated that reactance consisted of these two components (i.e., the perceived threat of freedom and anger scales) separately. However, as questions for the anger and threat of freedom scales were posed for both food options and the cafeteria board, we decided, based on the definition, to analyse them separately. This decision resulted in reactance comprising four subscales (i.e., two for threat of freedom and two for anger). Additionally, the analysis revealed that the seven items constituting the covariate for reactance attitude loaded onto one component. Moreover, the six items of inertia loaded onto one factor as well, separately for each scale.

Data pre-processing and assumption checks

To prepare the data for processing, first, the lists containing the total quantities sold of each item were used to compute two sum scores per timepoint, meaning one sum score for the total of vegetarian items sold (including vegan items), and one sum score for the total of sold items containing meat. It is important to note that no items containing fish were sold over this period. Similarly, sum scores of the answers were computed per timepoint for the dependent variables of the four reactance subscales and the inertia variable.

Subsequently, assumption checks for the chi-square tests were investigated. Violations are noted when relevant. Two outliers were detected in the reactance and inertia scales, respectively. However, since these outliers did not contain values outside of the possible score range, we decided to include the data of these participants in the analyses. Finally, the results of a one-way ANOVA and two Fisher's Exact Tests revealed that the three samples of the survey did not significantly differ regarding age, $F(2, 224) = 1.296$, $p = 0.276$, gender ($p = 0.370$), and diet ($p = 0.362$).

Main analyses

Behavioural Data. Initially, three chi-square tests of independence were employed to examine the relation between behavioural data (i.e., the number of units sold of vegetarian and meat items) and intervention implementation (indicated by the variable of time). Specifically, the first chi-square test compared T0 with T1 regarding the distributions of the number of purchased vegetarian and meat items, the second test examined the relationship between T0 and T2 in the same manner, and the third test investigated whether the distributions of the vegetarian and meat items differed for T1 and T2.

Survey data

Reactance. To investigate whether reactance changed over time after the intervention implementation, a Multivariate Analysis of Variance (MANOVA) was conducted in which the perceived threat of freedom (regarding food options and cafeteria board) and feelings of anger (regarding food options and cafeteria board) were set as outcome variables, whilst time (T0, T1, and T2) was used as a categorical predictor.

Inertia. To explore the relation between the intervention and inertia over time, a one-way Analysis of Variance (ANOVA) was conducted. Inertia was set as outcome variable, whilst time (T0, T1, and T2) was used as a categorical predictor.

Results

Main analyses

Behavioural data

Results are summarized in [Figure 3](#). The first chi-square test of independence demonstrated that the distribution of the number of sold vegetarian and meat items differed between T0 and T1, $\chi^2(1, N = 2,738) = 465.57$, $p < 0.001$, Cramér's $V = 0.41$, which is considered a strong effect. At the post-measure implementation, the sales of the number of vegetarian items increased ($n_{T0\text{vegetarian}} = 641$ versus $n_{T1\text{vegetarian}} = 1,325$), while the sales of the number of meat items decreased ($n_{T0\text{meat}} = 604$ versus $n_{T1\text{meat}} = 168$) as compared to the baseline measure.

The second chi-square test of independence yielded a significant difference between T0 and T2 in the pattern of the number of vegetarian and meat items sold, $\chi^2(1, N = 2,606) = 615.96$, $p < 0.001$, Cramér's $V = 0.49$, which is considered a strong effect. To be more precise, the number of vegetarian items sold was higher in T2 as compared to T0 ($n_{T0\text{vegetarian}} = 641$ versus $n_{T2\text{vegetarian}} = 1,283$), whilst the number of meat items exhibited an opposite trend ($n_{T0\text{meat}} = 604$ versus $n_{T2\text{meat}} = 78$).

The final chi-square test of independence elucidated that T1 and T2 slightly differed regarding the sales of the vegetarian and meat items, $\chi^2(1, N = 2,854) = 27.56$, $p < 0.001$, Cramér's $V = 0.10$, which is considered as a small effect. This analysis revealed that there was a small decrease from T1 to T2 in the sales of vegetarian items ($n_{T1\text{vegetarian}} = 1,325$ versus $n_{T2\text{vegetarian}} = 1,283$) and a slightly stronger decrease in the sales of meat items ($n_{T1\text{meat}} = 168$ versus $n_{T2\text{meat}} = 78$).

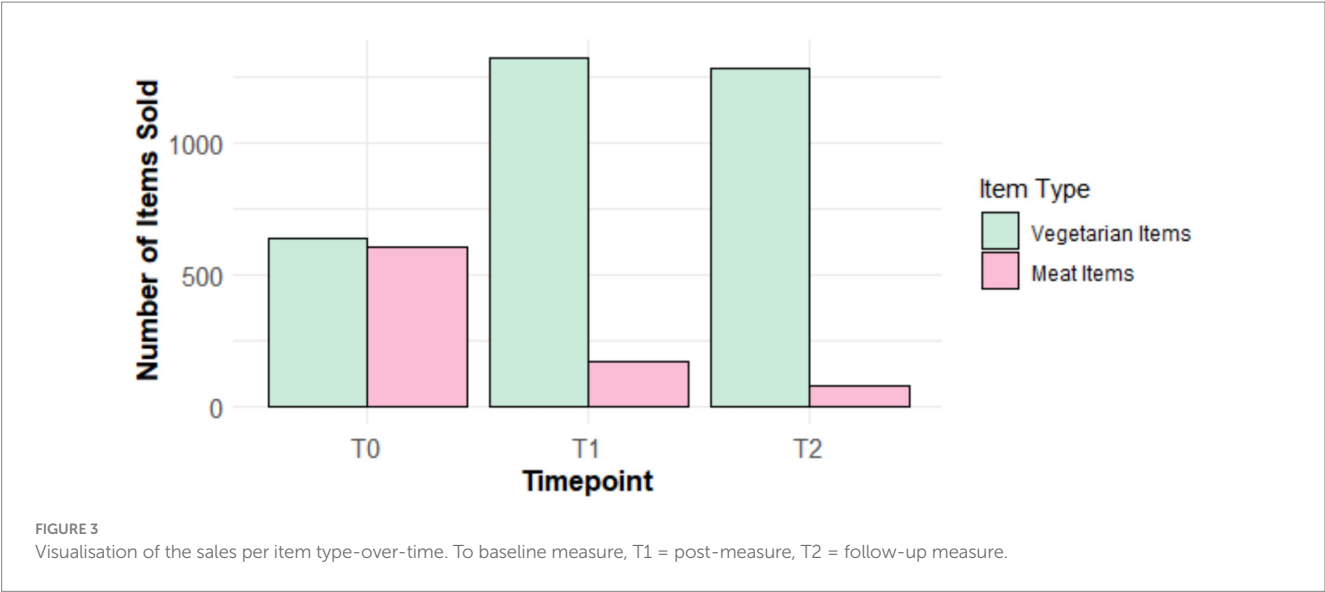


TABLE 1 Descriptive statistics of the dependent variables and covariates.

Dependent variable	Overall		T0		T1		T2	
	M	SD	M	SD	M	SD	M	SD
Perceived threat of freedom: food options	9.23	2.88	9.14	2.86	9.38	2.87	9.14	2.94
Perceived threat of freedom: cafeteria board	8.31	3.00	7.86	2.94	8.69	3.06	8.27	2.98
Anger: food options	7.70	3.37	7.54	3.53	8.20	3.50	7.30	3.07
Anger: cafeteria board	7.35	3.36	6.98	3.46	7.75	3.56	7.22	3.06
Inertia	13.76	5.21	13.83	5.37	14.29	5.05	13.13	5.25

Means and standard deviations are displayed for the overall variable of time and per timepoint. T0 = baseline measure, T1 = post-measure, T2 = follow-up measure.

Survey data

An overview of all descriptive statistics of the study is depicted in Table 1. All variables demonstrated deviations from normality. However, since the MANOVA and ANOVA are robust analyses which are not very sensitive to these deviations (Glass et al., 1972), we assumed little implications for our results and continued analyses as pre-registered.

Reactance. A MANOVA was conducted to investigate the association between the intervention implementation over time and reactance (i.e., composed of the two anger subscales and the two perceived threat of freedom subscales). The multivariate tests revealed no significant overall effect for Time, Pillai's Trace = 0.03, $F(2, 444) = 0.86, p = 0.554, \eta^2_p = 0.02$. This suggests that reactance, as indicated by the four subscales, did not change at the post-measure and at the follow-up measure as compared to the baseline measure (see Table 1).

Inertia. Furthermore, to examine the association between the default intervention and inertia over time, an ANOVA was employed. The results revealed no significant main effect of time, $F(2, 224) = 1.04, p = 0.357, \eta^2_p = 0.01$. This indicates that inertia did not increase nor decrease at the post-measure and the follow-up as compared to the baseline measure (see Table 1).

Discussion

The current study investigated whether the introduction of a vegetarian default is associated with a long-term promotion in the

selection of vegetarian items in a field experiment. Results indicate a strong significant interaction between time and the total number of food items sold, which was in line with our hypotheses. At baseline, no difference was found between the number of vegetarian and meat items sold. Yet, both right after implementation of the default as well as 10 weeks afterwards, the number of vegetarian items increased more than twofold, while the sales of meat items decreased by more than a third.

These findings are in line with, and expand upon, previous research (Campbell-Arvai et al., 2014; De Vaan et al., 2019; Gravert and Kurz, 2021; Hielkema et al., 2022; Meier et al., 2022; Taufik et al., 2022). In line with prior work, our results show that vegetarian defaults increase the demand for vegetarian items, whilst the demand for meat items decreases. Additionally, we expand upon prior research in two significant ways: First, this is the first study investigating the effects of a vegetarian default over a longer period (i.e., 16 weeks), which is notably longer than previous studies (e.g., Gravert and Kurz, 2021, and Taufik et al., 2022). This is important because it means that the default effect remains in place even after people realize meat options are still available. Second, our study contributes to the existing literature on vegetarian defaults and decision-making as prior research mainly concerned artificial choice scenarios, often in online or lab settings (e.g., Betz et al., 2022; Campbell-Arvai et al., 2014; De Vaan et al., 2019; Hielkema et al., 2022; Gravert and Kurz, 2021; Taufik et al., 2022). In contrast, our study examined real-life behaviour in a real-life setting. Therefore,

our results can be generalized to real-life settings such as companies or institutions with a cafeteria more easily, and support people who are interested in promoting ecologically sustainable food choices in their work environment. This high external validity and societal relevance is perhaps best demonstrated by the fact that the university cafeteria which was the object of this study, transitioned into a fully vegetarian food assortment after learning about the results of the current study.

In addition to the behavioural data, we also collected survey data regarding reactance and inertia to explore potential psychological side-effects of a vegetarian default intervention. A more exploratory approach was adopted in our analysis of these data, as we were less sure about clear hypotheses and directions of effects. No evidence was found for any effect of the intervention on participants' feelings of reactance and inertia, neither immediately after the intervention implementation, nor 10 weeks afterwards. Thus, the implementation of the vegetarian defaults could not be associated with significant changes in either reactance or inertia.

Regarding reactance, these findings align with earlier default interventions that found that vegetarian defaults are not related to a significant increase in reactance (Hertwig and Grüne-Yanoff, 2017; De Vaan et al., 2019). Another part of the literature stipulates that, along the lines of the change model (Lewin, 1947), reactance might increase shortly after intervention implementation and then decline again at the follow-up measurement due to acceptance of the new situation. Our results do not support this notion. A possible explanation for this might be that the individuals participating in the current study hold positive attitudes towards a vegetarian diet, and thus towards implementation of a vegetarian default, and showed therefore less reactance. However, this seems less likely given that reactance towards the food items was at a medium level across all three measurements. If positive attitudes were the main factor, reactance should have declined following intervention implementation. Thus, our research provides valuable reinforcement of existing knowledge indicating that freedom of choice is preserved when implementing vegetarian defaults and that vegetarian defaults are thus far not associated with a significant increase in reactance. It goes beyond current literature in such a way that these positive effects of the relation between vegetarian defaults and reactance (De Vaan et al., 2019) are established longitudinally in a real-world setting. This, in turn, improves the development of health, animal welfare, and sustainability improving strategies which do not evoke reactance.

Regarding inertia, our findings align with the notion that defaults do not increase nor decrease inertia across the three measures, which is in line with prior research (Joyner-Grantham et al., 2009; Knowles and Linn, 2004; Suri et al., 2013). Coupled with our observations in sales, we thus conclude that vegetarian defaults appear to be an effective strategy to encourage a shift towards a vegetarian diet among individuals who initially show inertia to such dietary changes.

Limitations and future research

The findings of the current study, encompassing behavioural and survey data, collectively indicate that vegetarian defaults seem an effective strategy to reduce meat consumption in a cafeteria

setting. Yet, we cannot state with absolute certainty that this can be achieved without provoking increased reactance since the survey responses were not necessarily provided by the customers that bought items and thus contributed to the behavioural data. We controlled for this by including regular patronage of the cafeteria as a criterion for participation. Hence, future studies could attempt to achieve tighter control between behavioural and self-report measures either by conducting research in a canteen where it would not cause disruption, or by implementing a more stringent inclusion criterion, such as requiring having purchased a meal that day, instead of merely being a regular customer. Nevertheless, as results of the study of De Vaan et al. (2019) did have the direct link between reactance data and item choice data, and did not show an increase in reactance, it seems less likely that reactance would have increased after exposure to the vegetarian default intervention.

Another limitation of our study, and inherent to field studies in general, is the limited control over the available food items. The availability and variety of both vegetarian and meat items changed over time when the intervention was implemented; specifically, the number of vegetarian items and its variety increased whilst those of meat items decreased. This adjustment was logical, as the canteen management aimed to avoid food waste and financial loss. Since the number of vegetarian items and its variety went up, this alone might have contributed to an increase in sales of these items, independent of the default set-up (Sethuraman et al., 2022). Ideally, future studies should maintain the number and variety of items constant across all time points, isolating the intervention's impact. If feasible, future studies should investigate this set-up, particularly if they can cover the financial costs for the participating canteen. However, the field study by Taufik et al. (2022) demonstrated that maintaining all options constant, except for one changed to a vegetarian default, significantly boosted its selection. This provides compelling evidence that the observed sales increase in our study might be attributed more to the impact of the vegetarian default set-up than to the typical effect of increased assortment.

Additionally, it is important to note that we chose not to exclude data from vegan and vegetarian participants for several reasons. First, including these diets provided a more complete representation of the general population, acknowledging the variability in dietary preferences across different settings. Even though the prevalence of vegetarians in our study was higher than in the general population, we believe that in various real-world settings, such prevalence fluctuates depending on the context. In addition, it is crucial to explore settings beyond the specific, highly educated population our study focused on, as this ensures results are applicable across a broader demographic spectrum, encompassing varied age groups, professions, and cultural backgrounds. Therefore, future research should explore this variability in diverse societal settings and with different target groups. From a health and environmental perspective, it is especially interesting to see whether people with a higher meat consumption respond similarly to such an intervention. Second, excluding vegetarian or vegan diets would not necessarily mean that the results differed. Our decision was informed by the nature of our survey, which focused on reactance related to the canteen's board and visible food items rather than specific food choices.

This approach allowed us to capture potential reactance among vegetarians and vegans, who, despite their dietary preferences, might still experience reactance against perceived paternalism. However, while vegetarians and vegans inherently exhibit the desired behaviour of not consuming meat and thus are less likely to experience inertia, our study's design, particularly the limitation regarding the missing connection between the survey and behavioural data, necessitated including all diets for a comprehensive analysis. Related to this, it would have been valuable to specifically examine the out-of-home buying and eating behaviour of different groups during the observation period. Thus, future studies should consider the possible effects of various diets and aim to represent a broader spectrum of society to improve generalisability.

Finally, since the effects of vegetarian defaults are now established, applying similar strategies with plant-based defaults might be a next step in reducing the carbon footprint of cafeterias (Fehér et al., 2020; Willett et al., 2019). However, it is important to proceed with caution as our findings cannot just be generalized to vegan default nudges. More specifically, while our research suggests that vegetarian defaults do not increase resistance or decrease sales, utilising plant-based defaults might lead to different results (De Groeve and Rosenfeld, 2022; Gregson et al., 2022; MacInnis and Hodson, 2017). Additionally, we do not know whether at-home eating was impacted by the food choices of customers, and it could be that people will eat more meat/fish (a rebound effect) or less meat/fish (a generalization effect). Recent research suggests that generalization effects (so-called positive spill-over effects) could be found in relation to more sustainable meat consumption in different settings (e.g., Graves and Roelich, 2021; Lanzini and Thøgersen, 2014; Nilsson et al., 2016). Therefore, future studies need to investigate whether adopting a plant-based default could potentially lead to similar positive results as those found in our study, or if it could instead lead to increased reactance or negatively impact sales. This would offer crucial insights for implementing such initiatives effectively.

Conclusion

This is the first field study that captures real behaviour in a natural setting, utilizes a large dataset, and provides longitudinal insights. In addition, this is the first study to explore the potential side-effects of a default nudging intervention by examining the relation with the psychological constructs of reactance and inertia. Our research helps to understand how nudging in the form of vegetarian defaults can effectively be utilised. The results are crucial for understanding the nuances of reactance and inertia in the context of food changes and organisational policies, offering a valuable foundation for future research and practical applications in similar settings. Based on our work, concerns about declining sales seem unwarranted. Moreover, our research aligns with the growing public and corporate interest in ecological sustainability, animal welfare, and health. We recommend to further investigate how vegetarian and vegan defaults can be established in canteens on a larger scale to support efforts to offer sustainable food choices in the public sphere. Our study suggests that implementing

vegetarian defaults might be a subtle, non-disruptive, and cost-efficient, yet effective and feasible behaviour change strategy. Such a policy would not require drastic changes from costumers and might have the potential to support a positive impact on ecologically sustainable and health-conscious choices.

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 humans were approved by Radboud University Social Sciences Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. SK-v: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – review & editing, Investigation. SN: Resources, Writing – review & editing, Writing – original draft. BM: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – review & editing, Investigation.

Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Almashadany, D. A. (2021). Meat borne diseases. *Meat Nutr* 163:96233. doi: 10.5772/intechopen.96233
- Appleby, M. C., Mench, J. A., and Hughes, B. O. (2004). Poultry behaviour and welfare. Wallingford, UK: CABI Publishing.
- Arnauodova, M., Brunner, T. A., and Götze, F. (2022). Examination of students' willingness to change behaviour regarding meat consumption. *Meat Sci.* 184:108695. doi: 10.1016/j.meatsci.2021.108695
- Betz, A. K., Seger, B. T., and Nieding, G. (2022). How can carbon labels and climate-friendly default options on restaurant menus contribute to the reduction of greenhouse gas emissions associated with dining? *PLoS Climate* 1:28. doi: 10.1371/journal.pclm.0000028
- Blake, J. (1999). Overcoming the 'value-action gap' in environmental policy: tensions between national policy and local experience. *Local Environ.* 4, 257–278. doi: 10.1080/13549839908725599
- Campbell-Arvai, V., Arvai, J., and Kalof, L. (2014). Motivating sustainable food choices: the role of nudges, value orientation, and information provision. *Environ. Behav.* 46, 453–475. doi: 10.1177/0013916512469099
- Carrington, M. J., Neville, B. A., and Whitwell, G. J. (2014). Lost in translation: exploring the ethical consumer intention-behaviour gap. *J. Bus. Res.* 67, 2759–2767. doi: 10.1016/j.jbusres.2012.09.022
- Crawshaw, J., Li, A. H., Garg, A. X., Chassé, M., Grimshaw, J. M., and Presseau, J. (2022). Identifying behaviour change techniques within randomized trials of interventions promoting deceased organ donation registration. *Br. J. Health Psychol.* 27, 822–843. doi: 10.1111/bjhp.12575
- De Groeve, B., and Rosenfeld, D. L. (2022). Morally admirable or moralistically deplorable? A theoretical framework for understanding character judgments of vegan advocates. *Appetite* 168:105693. doi: 10.1016/j.APPET.2021.105693
- De Vaan, J. M., van Steen, T., and Müller, B. C. (2019). Meat on the menu? How the menu structure can stimulate vegetarian choices in restaurants. *J. Appl. Soc. Psychol.* 49, 755–766. doi: 10.1111/jasp.12632
- Dillard, J. P., and Shen, L. (2005). On the nature of reactance and its role in persuasive health communication. *Commun. Monogr.* 72, 144–168. doi: 10.1080/03637750500111815
- Echegaray, F., and Hansstein, F. V. (2017). Assessing the intention-behaviour gap in electronic waste recycling: the case of Brazil. *J. Clean. Prod.* 142, 180–190. doi: 10.1016/j.jclepro.2016.05.064
- Eisnitz, G. A. (2009). Slaughterhouse: The shocking story of greed, neglect, and inhumane treatment inside the US meat industry. Amherst, US: Prometheus Books.
- EPRS (2020). Sustainable consumption: Helping consumers make eco-friendly choices. Brussels, BE: European Parliament.
- Eurobarometer (2023). Special Eurobarometer 538 climate change – report. Brussels, BE: European Commission.
- Farquhar, J. D., and Rowley, J. (2009). Convenience: a services perspective. *Mark. Theory* 9, 425–438. doi: 10.1177/1470593109346894
- Fehér, A., Gazdecki, M., Véha, M., Szakály, M., and Szakály, Z. (2020). A comprehensive review of the benefits of and the barriers to the switch to a plant-based diet. *Sustain. For.* 12:104136. doi: 10.3390/su12104136
- Fiber-Ostrow, P., and Lovell, J. S. (2016). Behind a veil of secrecy: animal abuse, factory farms, and ag-gag legislation. *Contemp. Just. Rev.* 19, 230–249. doi: 10.1080/10282580.2016.1168257
- Fishbein, M., and Ajzen, I. (1977). Belief, attitude, intention, and behaviour: an introduction to theory and research. *Philos. Rhetor.* 10:22.
- Glass, G. V., Peckham, P. D., and Sanders, J. R. (1972). Consequences of failure to meet assumptions underlying the fixed effects analyses of variance and covariance. *Rev. Educ. Res.* 42, 237–288.
- Godfray, H. C. J., Aveyard, P., Garnett, T., Hall, J. W., Key, T. J., Lorimer, J., et al. (2018). Meat consumption, health, and the environment. *Science* 361:5324. doi: 10.1126/science.aam5324
- González, N., Marquès, M., Nadal, M., and Domingo, J. L. (2020). Meat consumption: which are the current global risks? A review of recent (2010–2020) evidences. *Food Res. Int.* 137:109341. doi: 10.1016/j.foodres.2020.109341
- Gravert, C., and Kurz, V. (2021). Nudging à la carte: a field experiment on climate-friendly food choice. *Behav. Public Policy* 5, 378–395. doi: 10.1017/bpp.2019.11
- Graves, C., and Roelich, K. (2021). Psychological barriers to pro-environmental behaviour change: a review of meat consumption. *Behav. Sustain. For.* 13:11582. doi: 10.3390/su132111582
- Gregson, R., Piazza, J., and Boyd, R. L. (2022). 'Against the cult of veganism': unpacking the social psychology and ideology of anti-vegans. *Appetite* 178:106143. doi: 10.1016/j.appet.2022.106143
- Han, H., Kim, Y., and Kim, E. K. (2011). Cognitive, affective, conative, and action loyalty: testing the impact of inertia. *Int. J. Hosp. Manag.* 30, 1008–1019. doi: 10.1016/j.ijhm.2011.03.006
- Hertwig, R., and Grüne-Yanoff, T. (2017). Nudging and boosting: steering or empowering good decisions. *Perspect. Psychol. Sci.* 12, 973–986. doi: 10.1177/1745691617702496
- Hielkema, M. H., Onwezen, M. C., and Reinders, M. J. (2022). Veg on the menu? Differences in menu design interventions to increase vegetarian food choice between meat-reducers and non-reducers. *Food Qual. Prefer.* 102:104675. doi: 10.1016/j.foodqual.2022.104675
- JASP Team. (2023). JASP (version 0.18.3) [computer software]. Available online at: <https://jasp-stats.org/> (Accessed May 01, 2025).
- Joyner-Grantham, J., Mount, D. L., McCorkle, O. D., Simmons, D. R., Ferrario, C. M., and Cline, D. M. (2009). Self-reported influences of hopelessness, health literacy, lifestyle action, and patient inertia on blood pressure control in a hypertensive emergency department population. *Am J Med Sci* 338, 368–372. doi: 10.1097/MAJ.0b013e3181b473dc
- Kloosterman, R., Akkermans, M., Reep, C., Wingen, M., and van Beuningen, J. (2021). Klimaetverandering en energietransitie: opvattingen en gedrag van Nederlanders in 2020. Den Hague, NL: Centraal Bureau voor de Statistiek.
- Knowles, E. S., and Linn, J. A. (2004). Resistance and persuasion. New York, NY: Taylor & Francis Group.
- Kollmuss, A., and Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environ. Educ. Res.* 8, 239–260. doi: 10.1080/13504620220145401
- Laffan, K., Lades, L. K., and Delaney, L. (2023). Paths that lead astray: examining the situational predictors of intention-behaviour gaps in meat consumption. *J. Environ. Psychol.* 89:102045. doi: 10.1016/j.jenvp.2023.102045
- Lanzini, P., and Thøgersen, J. (2014). Behavioural spillover in the environmental domain: an intervention study. *J. Environ. Psychol.* 40, 381–390. doi: 10.1016/j.jenvp.2014.09.006
- Lehner, M., Mont, O., and Heiskanen, E. (2016). Nudging—a promising tool for sustainable consumption behaviour? *J. Clean. Prod.* 134, 166–177. doi: 10.1016/j.jclepro.2015.11.086
- Lewin, K. (1947). Group decision and social change. *Read. Soc. Psychol.* 3, 197–211.
- Lombardini, C., and Lankoski, L. (2013). Forced choice restriction in promoting sustainable food consumption: intended and unintended effects of the mandatory vegetarian day in Helsinki schools. *J. Consum. Policy* 36, 159–178. doi: 10.1007/s10603-013-9221-5
- Machovina, B., Feeley, K. J., and Ripple, W. J. (2015). Biodiversity conservation: the key is reducing meat consumption. *Sci. Total Environ.* 536, 419–431. doi: 10.1016/j.scitotenv.2015.07.022
- MacInnis, C. C., and Hodson, G. (2017). It ain't easy eating greens: evidence of bias toward vegetarians and vegans from both source and target. *Group Process. Intergroup Relat.* 20, 721–744. doi: 10.1177/1368430215618253
- Meier, J., Andor, M. A., Doebbe, F. C., Haddaway, N. R., and Reisch, L. A. (2022). Review: do green defaults reduce meat consumption? *Food Policy* 110:102298. doi: 10.1016/j.foodpol.2022.102298
- Monger, X. C., Gilbert, A. A., Saucier, L., and Vincent, A. T. (2021). Antibiotic resistance: from pig to meat. *Antibiotics* 10:1209. doi: 10.3390/antibiotics10101209
- Nilsson, A., Bergquist, M., and Schultz, W. P. (2016). Spillover effects in environmental behaviors, across time and context: a review and research agenda. *Environ. Educ. Res.* 23, 573–589. doi: 10.1080/13504622.2016.1250148
- Papies, E. K. (2017). Situating interventions to bridge the intention-behaviour gap: a framework for recruiting nonconscious processes for behaviour change. *Soc. Personal. Psychol. Compass* 11:12323. doi: 10.1111/spc3.12323
- Park, H. J., and Lin, L. M. (2020). Exploring attitude-behaviour gap in sustainable consumption: comparison of recycled and upcycled fashion products. *J. Bus. Res.* 117, 623–628. doi: 10.1016/j.jbusres.2018.08.025
- Parlasca, M. C., and Qaim, M. (2022). Meat consumption and sustainability. *Ann. Rev. Resour. Econ.* 14, 17–41. doi: 10.1146/annurev-resource-111820-032340
- Polites, G., and Karahanna, E. (2012). Shackled to the status quo: the inhibiting effects of incumbent system habit, switching costs, and inertia on new system acceptance. *MIS Q.* 36:21. doi: 10.25300/MISQ/2012/36.1.02
- Qualtrics. (2023). Qualtrics. Available online at: <https://www.qualtrics.com/> (Accessed May 01, 2025).
- R Core Team (2023). R: A language and environment for statistical computing. (version 4.3.2). Vienna, Austria: R Foundation for Statistical Computing.
- Rhodes, R. E., and de Bruijn, G. J. (2013). What predicts intention-behaviour discordance? A review of the action control framework. *Exerc. Sport Sci. Rev.* 41, 201–207. doi: 10.1097/JES.0b013e3182a4e6ed
- Rosenberg, B. D., and Siegel, J. T. (2018). A 50-year review of psychological reactance theory: do not read this article. *Motiv. Sci.* 4, 281–300. doi: 10.1037/mot0000091
- Roser, M. (2023). How many animals get slaughtered every day? Our World in Data. Available online at: <https://ourworldindata.org/how-many-animals-get-slaughtered-every-day> (Accessed December 18, 2023).

- Sethuraman, R., Gázquez-Abad, J. C., and Martínez-López, F. J. (2022). The effect of retail assortment size on perceptions, choice, and sales: review and research directions. *J. Retail.* 98, 24–45. doi: 10.1016/j.jretai.2022.01.001
- Suri, G., Sheppes, G., Schwartz, C., and Gross, J. J. (2013). Patient inertia and the status quo bias: when an inferior option is preferred. *Psychol. Sci.* 24, 1763–1769. doi: 10.1177/0956797613479976
- Taufik, D., Bouwman, E. P., Reinders, M. J., and Dagevos, H. (2022). A reversal of defaults: implementing a menu-based default nudge to promote out-of-home consumer adoption of plant-based meat alternatives. *Appetite* 175:106049. doi: 10.1016/j.appet.2022.106049
- Thaler, R. H., and Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. New Haven: Yale University Press.
- Van Dinther, M. (2015). Eens in de week geen vlees in de Radboud-kantine. *De Volkskrant*. Available online at: <https://www.volkskrant.nl/nieuws-achtergrond/eens-in-de-week-geen-vlees-in-de-radboud-kantine~b1948ac8/> (Accessed December 18, 2023).
- Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., et al. (2019). Food in the Anthropocene: the EAT–lancet commission on healthy diets from sustainable food systems. *Lancet* 393, 447–492. doi: 10.1016/S0140-6736(18)31788-4



OPEN ACCESS

EDITED BY

Christian Andreas Klöckner,
Norwegian University of Science and
Technology, Norway

REVIEWED BY

Adriana Zait,
Alexandru Ioan Cuza University, Romania
Simona Sulikova,
Independent Researcher, Washington, DC,
United States

*CORRESPONDENCE

Mark Wilson
✉ mw2640@bath.ac.uk

RECEIVED 31 January 2025

ACCEPTED 08 April 2025

PUBLISHED 20 May 2025

CITATION

Wilson M and Whitmarsh L (2025) Behavior
change interventions to promote adoption of
e-bike shared mobility in a rural area:
evidence from a mixed-method field trial.
Front. Psychol. 16:1569176.
doi: 10.3389/fpsyg.2025.1569176

COPYRIGHT

© 2025 Wilson and Whitmarsh. This is an
open-access article distributed under the
terms of the [Creative Commons Attribution
License \(CC BY\)](#). The use, distribution or
reproduction in other forums is permitted,
provided the original author(s) and the
copyright owner(s) are credited and that the
original publication in this journal is cited, in
accordance with accepted academic
practice. No use, distribution or reproduction
is permitted which does not comply with
these terms.

Behavior change interventions to promote adoption of e-bike shared mobility in a rural area: evidence from a mixed-method field trial

Mark Wilson^{1,2*} and Lorraine Whitmarsh^{1,2}

¹Department of Psychology, University of Bath, Bath, United Kingdom, ²Centre for Climate Change and Social Transformations (CAST), University of Bath, Bath, United Kingdom

Encouraging a shift to sustainable travel modes is essential for achieving net zero goals. This mixed-method study investigates the adoption of e-bike shared mobility in a rural context. Partnering with Cornwall Council and the shared e-bike provider Beryl, the study trialed two behavior change interventions to encourage people to use active modes; 151 residents and 14 Council staff took part. The two interventions were: (1) free Beryl bike credits, so people gain experience of using the e-bike share scheme on a trial basis, and (2) the 'Pen portraits' visioning tool, which uses evidence-based narratives to motivate people to consider how they could reduce car use in their daily lives. The effectiveness of the interventions was assessed over a four-week period through comparison to a control condition. During the study, uptake of e-bike share increased from 7 to 31% for residents, and from 29 to 71% for Council staff. Commuting and leisure or exercise were the most common journey purposes, although the bikes were also used as a component of multimodal travel. Beryl bikes encouraged mode shift for short journeys (1–2 miles), with 28% of e-bike share journeys substituting private car use, resulting in estimated carbon emission savings of 96–626 g CO₂ per journey. Relative to the control group, more people in each of the three intervention groups used a Beryl bike (Control group = 21% of residents used Beryl, compared to: the visioning tool = 31%; Beryl bike credits = 37%; and Beryl bike credits plus the visioning tool = 36%). However, these differences are not statistically significant. Participants reported strong agreement that e-bike share provides a range of practical benefits such as reduced concern about bike maintenance and theft, as well as co-benefits such as providing exercise and improving mental health. The article concludes with a discussion of the practical and analytical challenges for conducting behavior change interventions in real-world settings. These findings are relevant for local authorities who are interested in tools and behavioral approaches for engaging with the public on low-carbon travel.

KEYWORDS

behavior change intervention, mode shift, e-bike shared mobility, low-carbon travel, climate mitigation, local authority partnership

1 Introduction

Swift decarbonization is not only a technical challenge, but also a societal challenge that requires a fundamental shift away from high-carbon ways of living, and this positions people at the center of climate action (Moore et al., 2021; Verfuërth et al., 2024). In terms of engaging people to adopt low-carbon behaviors, local authorities have a key role to play in delivering contextually relevant infrastructural and regulatory interventions (Bulkeley et al., 2011). Local authorities also have an organizational role, with the capacity to introduce pro-environmental targets and working practices among their workforce, and so leading by example for other large employers. Local authorities are therefore increasingly interested in tools and behavioral approaches for mainstreaming climate action, engaging with the public, and maximizing impact with limited resources (Mees et al., 2019; Brauhnoltz-Speight et al., 2023).

Encouraging people to use sustainable modes of travel is one focus area for local authorities, not only because of the high emission intensity of private car use, but also the negative health impacts associated with air pollution (Allen et al., 2023; UK Health Security Agency, 2023). Municipal strategies include 'push' measures which discourage car use (e.g., traffic congestion charges), as well as 'pull' measures to encourage greater use of low-carbon modes (e.g., subsidized bus tickets) (Whitmarsh et al., 2021; Powell and James, 2023). One of these 'pull' strategies is providing shared mobility options, such as car clubs and public bike share schemes, which reduce the need for private vehicle use and ownership. The use of bike share, and e-bike share in particular, has seen a rapid increase in many countries in recent years. For example, the number of bike/e-bike share users in the UK has more than doubled since 2021; there are now over 2 million active users and e-bike share comprises 59% of all bike share journeys (CoMoUK, 2024). Considering this growing uptake, it is important for local authorities to understand how and why e-bike share is used in different contexts, and how effective it is in reducing carbon emissions.

The literature on bike/e-bike share focuses on users' journey purposes and identifying mode shift opportunities. One study finds a large proportion of dockless e-bike trips are for commuting and that the availability of the e-bikes and public transport services are key determinants of demand. The distances traveled by e-bike are comparable with the distances for public transport and taxi journeys (Guidon et al., 2019). Another study found awareness of e-bike share does not necessarily influence commuting behavior (Handy and Fitch, 2022). In terms of mode shift, one study finds e-bike share primarily substitutes public transport rather than car, and e-bikes are often used for the first or last mile of journeys (Bieliński et al., 2021). In contrast, two studies identify high car substitution rates of 37 and 28% (CoMoUK, 2022; Fukushima et al., 2023). Some authors find mode shift varies depending on the journey distance or purpose; for trips of less than one mile, shared e-bike is more likely to substitute walking, whereas for longer journeys or non-commute trips, shared e-bike is more likely to substitute car use (Fukushima et al., 2021). Multiple studies find significant carbon emission savings from using private e-bikes, relative to other modes (Winslott Hiselius and Svensson, 2017; Bucher et al., 2019; McQueen et al., 2020; Philips et al., 2022; Brand et al., 2022). Other authors focus specifically on e-bike share schemes and find emission reduction of up to 75% (Zhou et al., 2023), or 108–120 g CO₂ km (Li et al., 2023).

Several studies identify the predictors of bike/e-bike share adoption. Some authors highlight cost savings and convenience relative to using a car, a desire for physical exercise, and reduced concern around bike theft as key motivations (CoMoUK, 2022; Teixeira et al., 2023; Bartling, 2023). Perceived ease of use, perceived usefulness, and the positive opinions of others also encourage uptake (Li et al., 2022), in line with technology adoption theory (Straub, 2009). Other key factors include a high population density and the proximity of parking bays to public transport hubs, sports centers, and bike trails (He et al., 2019). The assisted power to cycle up steep hills, travel longer distances, and overcome health difficulties or low fitness levels is important for some users, which suggests e-bike share may play a role in making active travel more inclusive (Bieliński et al., 2021; CoMoUK, 2022). Investigating user profiles, students are typical early adopters but e-bike share is increasingly used by educated middle-aged workers (Julio and Monzon, 2022). E-bike share schemes encourage active travel among people aged 55 years or older (Fukushige et al., 2021). Men are more likely to use bike share than women (Barbour et al., 2019; CoMoUK, 2022), although e-bike sharing motivates women to make trips who would otherwise use a car (Fukushige et al., 2021). Some authors find road safety concerns and inconvenience are important barriers to adoption (Fishman et al., 2014).

A limited number of studies trialed interventions to encourage mode shift and their findings are promising. The loan of an e-bike for 2 weeks resulted in participants' habitual association with car use weakening significantly, both for participants who bought an e-bike after the trial and those who did not (Moser et al., 2018). A similar study found car use for commuting decreased from 88% before an eight-week e-bike loan to 63% 3 months later. E-bike use increased from 2 to 18% in the same period (Ton and Duives, 2021). A third study found the loan of an e-bike for 2–4 weeks did not influence those who regularly use a conventional bike, but it was effective at reducing car use amongst drivers (Fyhri et al., 2017). A more recent study, conducted in Cornwall, found 89% of participants reduced their car travel and 29% subsequently purchased an e-bike, following a 3-month loan of an e-bike (Shergold et al., 2023).

The broader behavior change evidence base highlights several important considerations for intervention design. Combining interventions (e.g., information and incentives) tends to be more effective than component interventions (Poortinga and Whitaker, 2018) because of the multiple drivers of behavior (including capability, opportunity and motivational factors detailed in the COM-B model; Michie et al., 2011). Importantly, information alone tends to be relatively ineffective for motivating pro-environmental behaviors (Nisa et al., 2019). Interventions which apply a co-benefits framing, for instance emphasizing potential health and environmental benefits, can support behavior change (Wolstenholme et al., 2020). Interventions to encourage car-reduction are most effective when they remove barriers to using alternative travel modes (e.g., cost, inconvenience) and are co-produced with communities to ensure a tailored approach that addresses local needs and increases perceived procedural fairness (Whitmarsh and Frost, 2024). However, the evidence base on car-reduction interventions remains methodologically weak, with few robust experimental field trials (Graham-Rowe et al., 2011; Okraszewska et al., 2024). Moreover, few behavior change studies quantify the environmental impact of the intervention. Finally, theoretical literature on technology adoption

explores the interplay of individual, technological, and societal factors that dictate how rapidly a technology will spread throughout society. The decision to adopt a new technology is rarely based solely on economic or pragmatic considerations, but encompasses social norms, values, and personal factors (Straub, 2009; Whittle and Whitmarsh, 2022).

In summary, there is extensive literature on the benefits and predictors of bike share adoption and e-bike ownership (Jones et al., 2016; de Haas et al., 2022; Winters et al., 2019; Biehl et al., 2019). The literature on e-bike share is emerging; when this study was conducted, the only previous studies in the UK context were a case study by Devon County Council (Thomas and Devon County Council, 2019) and an annual survey conducted by the charity Collaborative Mobility UK (CoMoUK, 2022). Reflecting the roll out of e-bike share schemes primarily in densely populated areas, previous studies have explored e-bike share adoption in large cities such as Shanghai, Sacramento, and Gdańsk (Zhou et al., 2023; Fukushima et al., 2023; Bieliński et al., 2021). The contribution of this study is twofold: (1) to investigate the uptake of e-bike shared mobility in rural settings, where travel behaviors and the context of adoption differ from cities, and (2) to test behavioral science approaches which local authorities can use to motivate modal shift.

This article reports the findings of an intervention study to encourage adoption of active modes of travel (i.e., walking, wheeling, or cycling). The study was conducted in Cornwall, a predominantly rural county in the southwest of the UK, and was co-designed with Cornwall Council, a unitary local authority. In 2022/23, Cornwall became one of the first rural counties in the UK to introduce an e-bike share scheme, through a partnership between the Council and the shared e-bike provider, Beryl. The Council were interested in ways to motivate uptake of Beryl bikes and two interventions were trialed with Cornwall residents and Council staff, measuring behavior change across a four-week period. The effectiveness of the interventions was assessed through comparison to a control condition. There were four aims of this study:

1. To measure participants' perceptions of e-bike share.
2. To understand how e-bike share is used in rural settings by characterizing users and investigating journey purpose, frequency, distance, and multimodal travel.
3. To quantify the potential mode shift emission reduction, from private car to e-bike share.
4. To determine whether the two behavior change interventions were effective in encouraging uptake of e-bike share and other sustainable modes.

2 Methodology

This is a mixed-method article; qualitative findings from an initial scoping study were used to inform the objectives and design of the behavior change intervention study.

2.1 Study 1—Focus groups

Online focus groups were conducted between December 2022 and January 2023 to explore Cornwall residents' ($n = 26$) views on the

feasibility of five low-carbon travel modes (public transport, active travel, car-sharing, electric vehicles, multi-modal travel) in the context of four frequent journeys (commuting to their place of work or study, shopping or accessing local services, leisure or visiting family and friends, and the school run, if applicable). Perceptions of the relative advantages and disadvantages of these travel modes were explored, along with the potential barriers and enablers of using each mode. The role of habits, key life events, social norms, and the expectations of household members on participants' travel behaviors were also investigated. Finally, participants ranked five 'push' measures to reduce travel-related carbon emissions (e.g., increased car parking charges in town centers), as well as five 'pull' measures (e.g., cheaper public transport). The anticipated effects of these measures on their travel behaviors were discussed. The focus group protocol can be found in [Supplementary material](#).

The study was promoted via Council communication channels such as their website and resident newsletters. Participants were recruited from five demographics to represent varying travel experiences and needs in Cornwall: urban residents; rural residents; young adults aged 16–22; people from low-income households; and people with a long-term health condition or disability. [Table 1](#) shows those with a disability were underrepresented in the final sample, but the sampling criteria were fulfilled for the remaining groups (i.e., a minimum of five participants per group). Participation was incentivized through a £20 gift voucher for each respondent. Council staff were not recruited for Study 1, as their views on sustainable travel had been collected in a previous study (see: [Player et al., 2022; Toy et al., 2023](#)).

The focus groups were recorded in Microsoft Teams and transcribed verbatim, anonymized, and then coded using deductive and inductive approaches to identify key themes in participants' responses (i.e., *a priori* codes based on the focus group questions, as well as emergent codes to reflect unanticipated themes). Thematic Analysis was used to identify, analyze, and report patterns (themes) within the qualitative data ([Braun and Clarke, 2006](#)). The themes were coded using Lumivero NVivo software. In terms of the researcher's positionality, I stated that I did not work for Cornwall Council, but was working with the Council to better understand the views of people who live in Cornwall. I encouraged the participants to express their opinions freely and emphasized there were no right or wrong answers.

2.2 Study 2—Behavior change intervention

The intervention study was conducted between May and July 2023. Two interventions were trialed to investigate their impact on the perceptions and travel behaviors of residents and Council employees. These interventions were selected by the researchers and Council partner based on the findings of Study 1 and on relevant empirical evidence and theory (particularly technology adoption theory and the COM-B model) that pointed to the importance of addressing individual, societal and technological factors:

1. Free credits to use Beryl bikes for 1 month. This intervention removed cost as an initial barrier and gave people direct experience of using shared e-bikes on a trial basis. This 'trial period' approach is consistent with previous intervention

TABLE 1 Sociodemographic characteristics of the focus group participants (residents, $n = 26$).

Sociodemographic characteristic	Frequency	%
Gender		
Female	15	57.7
Male	11	42.3
Have a longstanding health condition or disability	1	3.8
Are a young adult aged 16–22	5	19.2
Live in an urban area (i.e., suburbs or center of a large town or city) ^a	10	38.5
Live in a rural area (i.e., rural town or village)	16	61.5
Live in a low-income household ^b	5	19.2
Own or have regular access to a car	22	84.6
Have an undergraduate or postgraduate degree	16	61.5
Employment status		
Employed (full- or part-time) or self-employed	14	53.8
Retired	6	23.1
Student	5	19.2
Unemployed	1	3.8

^aUK Office for National Statistics definitions of 'urban' and 'rural' area were used, based on Census 2021 data.

^bA combined household income of less than £26,000 per year, before tax deductions.

studies which provided short-term e-bike loans to encourage the subsequent purchase of an e-bike (Fyhri et al., 2017; Moser et al., 2018; Ton and Duives, 2021).

- The 'Pen portraits' visioning tool (Prosser et al., 2022), adapted for the Cornish context. This tool presented stories of six evidence-based characters who have successfully reduced their car use and the study participants selected the character they most identify with. The intervention encouraged people to consider how they could reduce car use in their daily lives and highlighted potential co-benefits and positive lifestyle outcomes. Figure 1 is an example of a pen portrait; the image is accompanied by a one-page narrative about the depicted character. The visioning tool is available in [Supplementary material](#).

As with the focus groups, residents were recruited via Council communication channels. The participants were not given any information about the interventions prior to the study, but the recruitment material highlighted four inclusion criteria: (1) to have an interest in active modes of travel (to ensure participants would be physically fit enough to take part); (2) to own a smartphone (which is required to unlock and use a Beryl bike); (3) to live, work or study in one of the six towns in Cornwall where Beryl bikes are available; and (4) be aged 16 or over. Participation was incentivized through a £25 gift voucher for each resident who completed the study. Council staff were recruited through Beryl communication channels when they registered for an internal Council promotion of free Beryl bike credits. Staff participation in the study was incentivized through entry into a prize draw.

A 2×2 factorial design was used, whereby residents ($n = 200$) were randomly allocated to one of four interventions groups: (A) a control group; (B) the visioning tool only; (C) Beryl bike credits only; and (D) Beryl bike credits plus the visioning tool. Of the 200 residents who started the study, 151 completed all of the data collection activities listed below and were included in the final data set. Table 2

shows the number of participants in each group that completed the study. Council employees who registered for the free Beryl bike credits parallel intervention group C, but they were not randomly allocated to an intervention group. Of the 27 Council employees who chose to participate, 14 completed the study.

The participants were asked to complete the following data collection activities:

- A pre-intervention survey to measure current travel behaviors, perceptions of active travel and e-bike share, and sociodemographic characteristics. This survey highlighted the availability of Beryl bikes in their local area.
- A weekly travel diary for four consecutive weeks to measure Beryl bike journey frequency, distance, purpose, and mode shift. Aggregated, observed travel data from Beryl, the company which operates the shared e-bikes, provided further insights on journey frequency and distance.
- A post-intervention survey to measure any changes in perceptions or travel behaviors, and users' satisfaction with Beryl bikes.

These data collection tools (see [Supplementary material](#)) were developed by adapting questions from previous travel behavior studies (CoMoUK, 2022; Wilson and Whitmarsh, 2023) or, where precedent questions were unavailable, bespoke questions were designed to explore themes of interest.

For research aim 1, participants' perceptions of 15 attributes of Beryl bikes were measured to understand which aspects of e-bike share may appeal to them. The attributes were selected by incorporating findings from the focus groups and duplicating some of the attributes measured in the CoMoUK survey (2022). Participants were asked to indicate their level of agreement, on a five-point Likert scale, that using Beryl bikes would help them personally by providing these benefits. Their perceptions were measured in the pre- and



FIGURE 1
Pen portrait 2—a young adult living in an urban area in Cornwall.

TABLE 2 Study design—the four intervention groups.

	Visioning tool: NO	Visioning tool: YES
e-bike credits: NO	A. control group ($n = 44$)	B. visioning tool only ($n = 36$)
e-bike credits: YES	C. e-bike credits only ($n = 38$) Parallel study with Council staff ($n = 14$)	D. e-bike credits + visioning tool ($n = 33$)

post-intervention surveys to explore whether direct experience of using the bikes may influence their views.

For research aim 2, participants were presented with nine potential barriers in the post-intervention survey and asked which are the three main barriers to people using Beryl bikes in Cornwall. Participants also provided qualitative feedback on using e-bike share. This data was combined with travel diary responses on journey purpose, distance and mode shift to understand how e-bike share is used in rural settings.

Research aim 3 was to quantify the environmental impact of shared e-bike journeys replacing car journeys. This was achieved through a Life Cycle Assessment synthesis, an established approach for estimating the emission reduction associated with the adoption of a low-carbon behavior (Ivanova et al., 2020; Wilson et al., 2020). Quantitative estimates of the emission intensity of (1) car journeys and (2) e-bike or shared e-bike journeys were compiled from existing Life Cycle Assessment studies. These estimates produced a range of grams of CO₂ per km (or grams of CO₂-equivalent per km) for the two travel modes. Empirical data collected during this study, on participants' shared e-bike journey frequency, distance, and mode shift, was situated

within these emission intensity ranges. The emission reduction of shared e-bike substitution of car journeys was calculated *per person per journey*, and *per person per year*. The full calculations are presented in [Supplementary material](#).

For research aim 4, the success of the interventions was determined by a dichotomous dependent variable: to have used OR not used a Beryl bike during the study period. Participants who received the visioning tool intervention (groups B and D) were asked three additional questions about the relevance of the tool to their lives and the potential impact of the tool on their travel behavior. A range of between-group and within-group statistical tests were used to measure differences in behaviors and attitudes: independent-samples t-test, Welch t-test, paired samples t-test, Chi-square test of homogeneity, and Fisher's exact test. The statistical analysis was conducted using IBM SPSS software.

Table 3 is an overview of the intervention participants' sociodemographic characteristics. Compared to Census 2021 data, this sample of residents is broadly representative of Cornwall's population for age, ethnicity, low-income groups, and health condition or disability. However, it differs for gender, education, employment status, household composition and location (women,

TABLE 3 Sociodemographic characteristics of intervention study participants.

Sociodemographic characteristic	Residents (<i>n</i> = 151)		Council staff (<i>n</i> = 14)	
	Frequency	%	Frequency	%
Gender				
Female	90	59.6	8	57.1
Male	56	37.1	5	35.7
Non-binary	3	2.0	1	7.1
Ethnicity				
White British/White Cornish	138	91.4	14	100.0
Asian/Asian British	3	2.0	-	-
Mixed/Multiple ethnic groups	1	0.7	-	-
Other ethnic group	5	3.3	-	-
Have a longstanding health condition or disability	25	16.6	2	14.3
Have children (under 18) living at home	52	34.4	9	69.2
Live in an urban area ^a	72	47.7	7	50.0
Have an undergraduate or postgraduate degree	94	62.3	10	71.4
Employment status				
Employed (full- or part-time) or self-employed	116	76.8	14	100.0
Retired	17	11.3	-	-
Looking after family/ home	7	4.6	-	-
Student	4	2.6	-	-
Unemployed	1	0.7	-	-
Live in a low-income household ^b	35	23.2	1	7.1
Own a bike or e-bike in good working order	81	53.6	12	85.7
Own or have regular access to a car	130	86.1	13	92.9
Mean age (in years)	46.5 years		41.1 years	

^aUK Office for National Statistics definitions of 'urban' and 'rural' area were used, based on Census 2021 data.

^bA combined household income of less than £26,000 per year, before tax deductions.

people with an undergraduate or postgraduate degree, those who are economically active, families with dependent children, and those who live in an urban area are all overrepresented in this sample).¹ In terms of available travel options, the majority of residents in this study (86.1%) own a vehicle and almost half (48.3%) have two or more vehicles in their household. Similarly, most Council staff (92.9%) own a vehicle and over three quarters (76.9%) have two or more vehicles in their household. The study samples therefore have higher levels of vehicle ownership than the England average (78%), as well as higher levels of multiple vehicle households than the England average (33%) (Department for Transport 2022). This likely reflects a greater dependency on cars in rural areas. Owning a bicycle is another factor which could influence an individual's uptake of e-bike share. Most Council staff

(85.7%) and just over half of residents (53.6%) own a bicycle or e-bike that is in good working order.

3 Results

3.1 Study 1—Focus groups

The focus groups explored residents' perceptions on a wide range of travel-related themes and only the findings that are most relevant to the design of the intervention study are presented here. Several participants described their dependency on cars because they live in rural areas and must travel long distances to get to work or access local services (*n* = 15): "My work is 35 miles away, so unfortunately that is a no go on public transport." Additional determinants of car use include convenience (*n* = 6) and the need to transport shopping or passengers (*n* = 5): "I'll collect all my clients in my car...and take them to the activity." Many did not consider public transport viable due to a lack of services or poor connectivity in their area (*n* = 16): "The last bus back is 20 [minutes] to 6 at night...so you can't go out in the evening using public transport at all." A further barrier was the infrequency and unreliability of services (*n* = 14): "The other thing is waiting for buses that never come." Some use multimodal travel to avoid traffic

1 See Census 2021: <https://www.ons.gov.uk/visualisations/censusareachanges/E06000052/>; <https://www.ons.gov.uk/peoplepopulationandcommunity/educationandchildcare/bulletins/educationenglandandwales/census2021>; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/88141/cornwall-and-isles-of-scilly.pdf.

congestion in towns and save money on parking fees ($n = 9$): *"It costs a fortune...to park. So I will drive...park my car, then cycle the rest of the way."* In terms of policies to reduce car travel, participants reported a strong preference for 'pull' measures which make sustainable alternatives easier or cheaper, rather than push measures which restrict car use or make it more expensive.

3.1.1 Benefits of active modes of travel

Most participants expressed an interest in using active travel more frequently and described multiple benefits. The most frequently mentioned was providing exercise and improving physical health ($n = 7$): *"If I don't go cycling at least twice a week, my knees go all rubbish, you know? So, as an older person, it keeps me in tip-top condition."* Improving wellbeing and mental health was equally important ($n = 7$): *"What do I enjoy about cycling now? It's meditative...it's for an enjoyment aspect. I enjoy the action of cycling."* A related benefit was that using active modes provides an opportunity to be outside and experience being in nature, particularly for those whose job involves being indoors for much of the time ($n = 5$): *"It's more pleasurable, I would say. If it's not raining, you know, you get the air, you just feel more alive, don't you? You can appreciate your surroundings, it's a nice feeling."* Some participants identified cost savings, relative to other travel modes ($n = 4$): *"It's great that you get to work for free and you get fit while you're doing it."* Other reported benefits include socializing by cycling as a group ($n = 2$) and reducing carbon footprint from avoiding car use ($n = 2$). Journey purpose and distance were important determinants of travel mode choice. For short journeys, many participants preferred to use active modes ($n = 11$): *"If it's less than three miles, I prefer walking. That's how I like to get around."*

3.1.2 Barriers to using active modes of travel

Despite these perceived benefits, residents identified multiple barriers to using active modes in Cornwall, especially for cycling. The most prevalent concern was safety when sharing the road with vehicles, particularly on narrow country roads ($n = 19$): *"The two miles between my house and Saltash where the cycle lane starts, it's just deadly. So it's not something that I'm even considering doing."* A related barrier was the lack of cycle lanes and walking paths in rural areas ($n = 15$): *"There's just a lack of infrastructure until you get somewhere close to a kind of urban area, then you have cycle paths and things like that. And even then, it's pretty limited."* Where cycle lanes are available, some participants described the routes as poorly maintained ($n = 4$) or badly designed; for example, ending unexpectedly at a busy junction ($n = 5$). In the preference ranking exercise, investment in active travel infrastructure was the second most popular 'pull' policy, after investment in public transport.

Participants also highlighted other barriers such as wet and windy weather during the winter months ($n = 9$) and the topography in Cornwall which is characterized by steep hills ($n = 7$): *"I think it's too steep to cycle around here. Yeah, I don't think I've got my bike out since, it's exhausting!"* A lack of secure bike storage in town centers and workplaces was another challenge ($n = 6$): *"There aren't many specific bike racks that I see, so we'll just lock them to a fence or something."* This barrier was particularly emphasized by those who own expensive bicycles and were concerned about theft. Other barriers included limited carrying capacity on bikes ($n = 3$), a lack of showering facilities

at their place of work ($n = 2$) and experiencing air pollution when cycling ($n = 2$). Many of the barriers described above correspond with the findings of a previous study which investigated perceptions among the Council workforce (Player et al., 2022; Toy et al., 2023).

3.1.3 Perceptions of e-bikes and e-bike share

One notable theme to emerge during the focus groups was residents' views on e-bikes and how they counteract some of the physical barriers to using active modes. Six participants owned an e-bike and described how using one reduces journey time and mitigates the difficulty of cycling up steep hills ($n = 6$): *"Over the hills are too much for an ordinary bicycle. Electric bike makes all the difference."* One respondent described how using his e-bike provides more personal comfort, as it enables him to arrive at work without being sweaty and fatigued. Participants were also generally positive about e-bike share schemes ($n = 4$): *"The e-bikes around cities, yeah, I think it's a good idea. Obviously, it's not relevant for us living in more rural communities. There's only been two or three places I should think in Cornwall that it would work."* That e-bike share was considered suitable only for urban areas relates primarily to road safety concerns, but also the view that the financial investment required to launch the scheme was not justifiable for smaller towns where most amenities are within walking distance ($n = 2$).

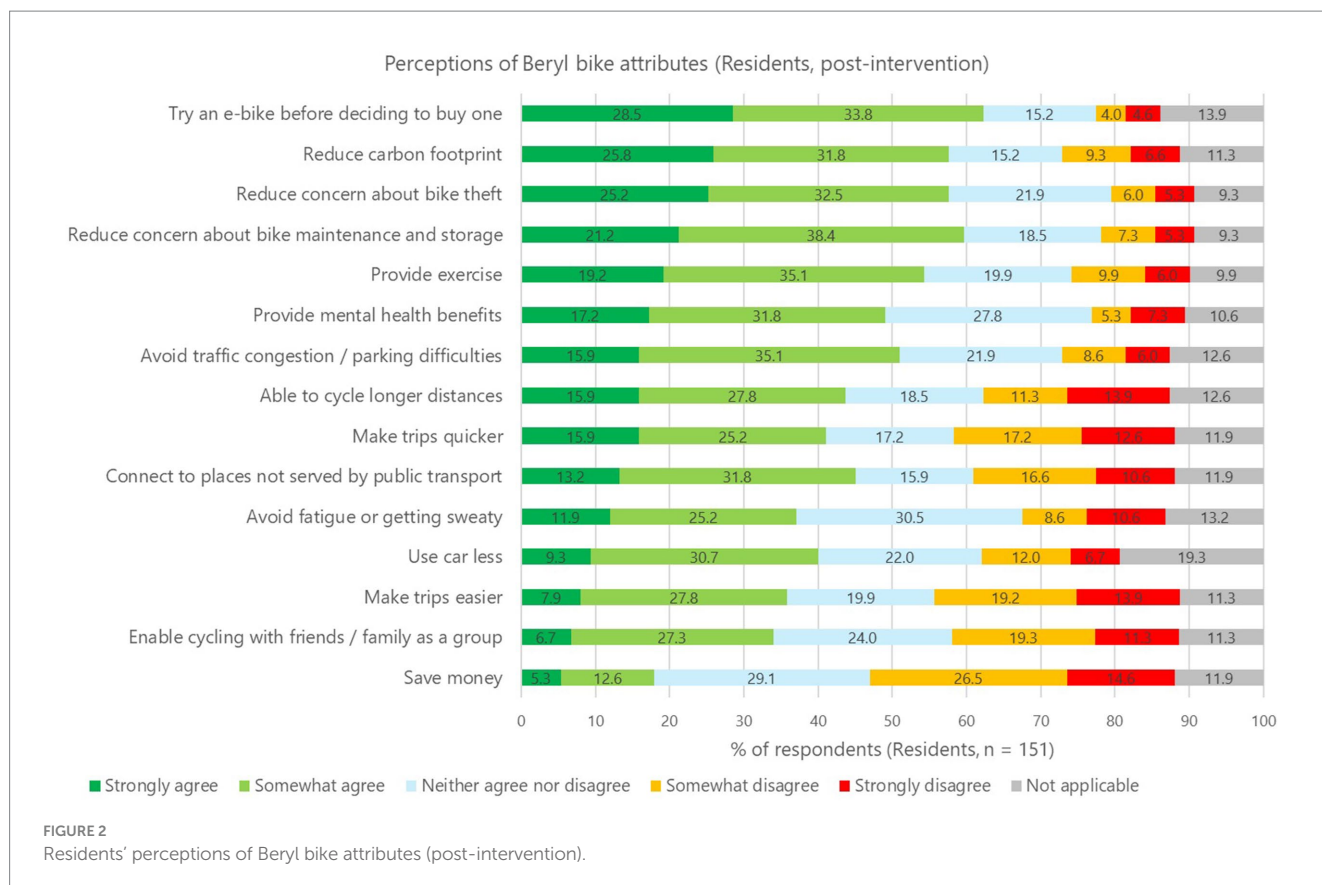
3.1.4 Intervention design

When co-designing the behavior change intervention, Cornwall Council had a particular interest in encouraging and enabling more people to use active modes of travel, due to its potential to reduce carbon emissions as well as provide the health and wellbeing benefits described by the focus group participants. Addressing the most important barriers, road safety concerns and a lack of active travel infrastructure, requires long-term regional planning and significant fiscal investment, and so were beyond the scope of this pilot study. The decision to focus on the recently introduced e-bike share scheme was due to its potential to overcome two of the other barriers; shared e-bikes provide assisted power to cycle up steep hills, and they remove apprehension about the lack of secure bike storage. Moreover, using e-bike share aligns with the participants' positive perceptions of using active modes, particularly for shorter journeys. Given the rural context, the Council were also interested in whether people would combine e-bike share with other travel modes for longer journeys.

3.2 Study 2—Intervention study

3.2.1 Perceptions of e-bike share

This study measured participants' perceptions of 15 attributes of Beryl bikes to understand which aspects of e-bike share may appeal to them. Although residents tended to rank the attributes slightly higher in the post-intervention survey, none of the differences are statistically significant (paired samples t-tests, see [Supplementary material](#)) and so there is no clear evidence of a change in their perceptions during the study period. Post-intervention survey findings for residents ($n = 151$) are presented in [Figure 2](#), with the highest ranked attributes located at the top of the chart. [Figure 2](#) shows practical attributes are important, for example, *trying an e-bike before buying one* is the highest ranked attribute, with 62.3% of residents stating they 'somewhat agree' or 'strongly agree' that Beryl



bikes provides this benefit (i.e., the green segments in each bar). Moreover, there is broad agreement that using Beryl bikes *reduces concerns around maintaining a bike* (59.6%) and *bike theft* (57.7%), and *avoids traffic congestion and parking difficulties* (51.0%). Co-benefits are also important; 57.6% of residents believe that using Beryl bikes will *reduce their carbon footprint*, and there is strong agreement that Beryl bikes provide *exercise* (54.3%) and *mental health benefits* (49.0%). The lowest ranked attribute is *cost* (17.9%), as Beryl bikes are considered expensive to use. Council staff reported stronger agreement than residents for all attributes, although the small sample size for Council staff limits our ability to make comparisons between the two groups. The post-intervention findings for Council staff can be found in [Supplementary material](#).

There are personal factors which may influence the adoption of e-bike share, even if participants have a positive perception of the scheme. As discussed earlier, the participants reported high levels of vehicle and bicycle ownership and so have multiple existing travel options. Interestingly, a high proportion of residents (60.9%) and Council staff (78.6%) indicated that they would like to reduce their vehicle use. Moreover, the majority of residents (70.2%) and Council staff (92.9%) are confident in their ability to ride an e-bike, although one in seven residents (13.9%) stated that walking or cycling as a main mode of travel is not feasible due to a longstanding health condition or disability. E-bikes are relatively expensive and two-thirds of residents (66.2%) expressed concerns that if they owned one, they would worry about it getting stolen. This may explain the high ranking of *reduce concern of bike theft* as one important attribute of e-bike share. Overall, these personal factors support the uptake of e-bike share.

Table 4 presents the findings of between-group analyses of residents' perceptions of Beryl bikes. Those who used a Beryl bike during the study tended to rate the attributes higher than non-users, although only one difference is statistically significant; Beryl bike users reported stronger agreement that using the bikes would make their trips easier. People living in rural areas and those on lower incomes reported stronger agreement that using Beryl bikes would enable them to use their car less, and avoid traffic congestion and parking difficulties. People living in rural areas also reported stronger agreement that using Beryl bikes would connect them to places not served by public transport, enable them to try an e-bike before deciding whether to buy one, and provide exercise and mental health benefits. People on lower incomes reported stronger agreement that Beryl bikes would make their trips easier and avoid fatigue before work or socializing. There were no statistically significant differences in the level of agreement based on other grouping variables such as gender, education level, owning a bike, or driving intention (independent samples t-tests).

3.2.2 Uptake of Beryl bikes during the study

During the study, uptake of Beryl bikes increased from 6.6 to 30.5% for residents, and from 28.6 to 71.4% for Council employees.² This relatively large increase suggests that participation in this study

² A Fisher's exact test revealed this difference in the proportions (0.409) of Council employees and residents who used a Beryl bike during this study is statistically significant, $p = 0.005$. However, one of the expected cell counts

TABLE 4 Between-group analyses of residents' perceptions of Beryl bikes (independent samples t-test).

Attribute of Beryl bikes	Grouping variable	M	SD	MD	df	t	p	95% CI	
								Low	High
Make trips easier	Beryl bike user	3.35	1.25	0.55	132	2.411	0.017	0.10	1.01
	Non-Beryl bike user	2.80	1.20						
Use car less*	Rural resident ^a	3.60	0.90	0.65	98	3.270	0.001	0.26	1.05
	Urban resident	2.95	1.24						
Avoid traffic congestion/parking difficulties	Rural resident	3.74	1.04	0.47	130	2.461	0.015	0.09	0.85
	Urban resident	3.27	1.14						
Try an e-bike before deciding to buy one	Rural resident	4.10	0.97	0.44	128	2.330	0.021	0.07	0.81
	Urban resident	3.66	1.17						
Provide exercise*	Rural resident	3.78	0.98	0.45	115	2.277	0.025	0.06	0.84
	Urban resident	3.33	1.27						
Provide mental health benefits	Rural resident	3.81	1.00	0.62	133	3.303	0.001	0.25	0.98
	Urban resident	3.19	1.16						
Connect to places not served by public transport	Rural resident	3.45	1.16	0.47	131	2.160	0.033	0.04	0.89
	Urban resident	2.98	1.34						
Use car less*	Low-income household ^b	3.88	0.77	0.77	64	3.876	0.001	0.37	1.16
	Higher income household	3.12	1.18						
Avoid traffic congestion/parking difficulties*	Low-income household	3.86	0.76	0.45	73	2.326	0.023	0.06	0.83
	Higher income household	3.41	1.22						
Make trips easier	Low-income household	3.41	1.21	0.55	121	2.106	0.037	0.03	1.07
	Higher income household	2.86	1.24						
Avoid fatigue or getting sweaty before work or socializing	Low-income household	3.64	1.16	0.53	118	2.130	0.035	0.04	1.03
	Higher income household	3.11	1.16						

^aUK Office for National Statistics definitions of 'urban' and 'rural' area were used, based on Census 2021 data.

^bA combined household income of less than £26,000 per year, before tax deductions.

*Levene's test revealed unequal variances and so Welch t-test findings are reported, rather than the independent samples t-test findings.

motivated some participants to adopt Beryl bikes, particularly Council staff. For residents, a higher proportion of bike owners (33.3%) than non-bike owners (27.1%) used a Beryl bike during this study, but the difference is not statistically significant (Fisher's exact test, difference in proportions = 0.062, $p = 0.479$). Similarly, a higher proportion of car owners (32.3%) than non-car owners (19.0%) used a Beryl bike during this study, but the difference is not statistically significant (Fisher's exact test, difference in proportions = 0.133, $p = 0.308$). Considering whether driving intention might be relevant to the uptake of Beryl bikes, a higher proportion of residents who are interested in reducing their car use rode a Beryl bike during this study (38.0%) than those who are not interested in reducing their car use (22.2%). However, this difference is not statistically significant (Fisher's exact test, difference in proportions = 0.158, $p = 0.168$). The sociodemographic characteristics of Beryl bike users resemble the broader study sample: a relatively young mean age, although 13.0% of Beryl users are aged 60 or over; a

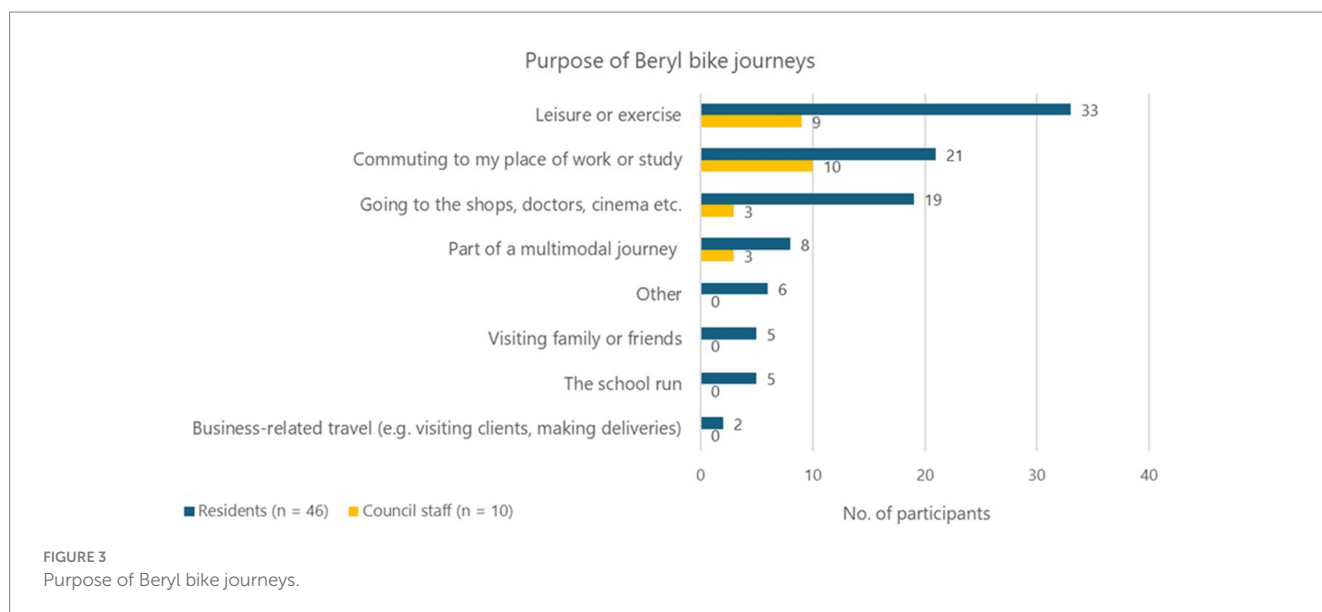
minority have a longstanding health condition; and most own a bicycle and a car and so have multiple travel options. In summary, the adoption of e-bike share in Cornwall cannot be explained by bicycle or vehicle ownership, driving intention, nor by sociodemographic profile.

Beryl bikes were effective at re-engaging non-cyclists; hiring a bike encouraged one in six residents (14.7%) to try cycling again after a break of 5 years or more. In addition, approximately one in five residents (17.6%) and Council staff (20.0%) started cycling after a shorter break. This suggests that e-bike share schemes encourage the uptake of cycling among people who may have a lower propensity to use active modes.

3.2.3 Journey purpose

The purpose of the participants' Beryl bike journeys was investigated to understand how using shared e-bikes may fit with their daily activities and travel needs. Anyone who used a Beryl bike was asked to indicate the purpose(s) of their Beryl bike journeys during that week (participants could select multiple options). [Figure 3](#) shows that *leisure or exercise* and *commuting* were the most commonly reported journey purposes for both residents and Council staff. *Going to the shops* or accessing other local services was another common

was less than 5 and this low sample size invalidates this finding (Hollander and Wolfe, 1999).



journey purpose, particularly among residents. In contrast to the frequency of commute journeys, *business-related travel* (e.g., *visiting clients*) was the least reported journey purpose. The data for the proximity of Beryl bike parking bays to the participants' home or their place of work can be found in [Supplementary material](#).

The focus groups revealed that many people in Cornwall live in rural areas and so require either a car or public transport to access towns and local services, and this is a clear barrier to shifting to active modes of travel. Cornwall Council were interested in whether e-bike share could be combined with other travel modes, whereby a Beryl bike is used for the segment of the journey within the town (i.e., the first or last mile). [Figure 3](#) shows 11 participants used Beryl bikes as a component of multimodal travel. These participants were asked which travel modes they combined with Beryl bikes; *car* (as a driver and as a passenger) and *bus* were the most common responses ([Table 5](#)).

3.2.4 Journey distance, frequency and mode shift

This study explored the extent of Beryl bike use by asking participants to record their journey distances, frequency and mode shift in the travel dairies. Aggregated, observed data on journey frequency and distance was also available from Beryl, the service provider. [Table 6](#) presents the mean distances for the two samples and two data sets, resulting in a range of 2.06–3.21 km per journey (or 1.28–1.99 miles per journey).³ Beryl bikes are therefore used primarily for short journeys, although longer journeys of 4 or 5 km were not uncommon. For residents and Council staff, the reported distances are slightly longer than the observed distances from Beryl bike data, although the two data sets are not directly comparable because they comprise different sample sizes and study period durations. Nevertheless, the range of 2.06–3.21 km per journey provides a useful indication, and is consistent with shared e-bike

TABLE 5 Travel modes combined with Beryl bikes in multimodal journeys.

Mode of travel combined with Beryl bike	Residents' (n = 8) no. of multimodal journeys	Council staff's (n = 3) no. of multimodal journeys
Car/van as a driver	5	3
Bus	5	0
Car/van as a passenger	4	2
Train	2	2
Other	3	0
Taxi	0	0
E-scooter/scooter/motorcycle	0	0

journey distances identified in previous studies ([Fukushige et al., 2021](#); [Zhou et al., 2023](#)). A further finding is the relatively infrequent use of Beryl bikes during study period, with the mean number of journeys ranging from 0.8 to 1.5 per rider per week. This suggests many participants were trialing Beryl bikes and that using e-bike share was not yet embedded in their daily travel routine.

Participants were asked which mode of transport they would have typically used for their journey(s) before they started using the e-bike share scheme. [Figure 4](#) reveals *walking* (39.3%) and *using my own vehicle* (27.9%) were the most commonly substituted travel modes (for residents and Council staff combined). However, the adoption of Beryl bikes did not reduce the overall time spent walking or wheeling each week (see [Supplementary material](#)).

3.2.5 Carbon emission reduction

A Life Cycle Assessment synthesis was conducted to quantify the carbon emission reduction of e-bike share substitution of car journeys. Emission reduction ranges are provided below, rather than a single emission reduction figure, due to variation in the quantitative estimates and system boundaries of the Life Cycle Assessments, as well as variation in how residents and Council staff used Beryl bikes. For

³ A range is provided, rather than a single mean distance, because: (a) there are two participants groups in this study, residents and Council staff, and (b) two different data sets, the travel dairies (reported data) and Beryl data (observed data).

TABLE 6 Mean number of journeys and mean distance per journey.

Group	Mean no. journeys per rider over the study period	Mean no. journeys per rider per week	Mean distance (km) per journey
Residents (reported data, $n = 41$, over 4 weeks)	3.2	0.8	3.21 ^a
Residents (observed data, $n = 34$, over 10 weeks)	8.5	0.8	2.99
Council (reported data, $n = 10$, over 4 weeks)	6.0	1.5	2.43
Council (observed data, $n = 9$, over 10 weeks)	9.1	0.9	2.06

^aFive outliers were removed, because they reported very long journey distances, relative to the rest of the resident sample and to the Council staff sample. Thus, the residents' reported journey distances in Table 6 may be an underestimate.

the participants in this study, the estimated emission reduction was 96–626 g CO₂e per journey. This is a significant emission saving for a single journey. The annual carbon emission reduction due to mode shift from cars to shared e-bikes is 1.1–13.6 kg CO₂e per person per year. For context, 13.6 kg CO₂e per person per year is equivalent to 1.2% of the annual road and rail travel carbon footprint of a Cornwall resident (Cornwall Council, 2022). Thus, the annual emission reduction is modest and this is due to the relative infrequency of Beryl bike journeys made by the participants in this study, and that a significant proportion of e-bike share journeys substitute for walking rather than car use. The complete emission reduction calculations are presented in [Supplementary material](#).

3.2.6 Barriers to the uptake of Beryl bikes

Table 7 shows road safety concerns was the most important barrier, reflecting the findings of Study 1. Other key barriers are cost and the location of the parking bays.

Participants' qualitative feedback revealed other reasons for not using a Beryl bike. For instance, a Beryl bike may not be suitable for particular journey purposes such as when people need to transport passengers or bulky items ($n = 5$), or do a big food shop ($n = 7$): "I needed more storage space to carry my groceries home." For work-related travel, some participants were uncertain if they could cycle to their destination on time ($n = 3$): "All required journeys this week were...time sensitive." Suggestions for improving the scheme included allowing a short pause in the journey without being required to park the bike in a bay ($n = 5$), providing a helmet with the bike ($n = 7$), and catering for families by adding child seats or providing smaller e-bikes ($n = 9$). These insights reveal that specific daily activities and responsibilities can play an important role in people's choice of travel mode, even if they support using e-bike share.

3.2.7 Behavior change intervention results

Figure 5 indicates that the first intervention, free credits to use Beryl bikes for 1 month, was more effective than the second intervention, the pen portraits visioning tool, for encouraging uptake of e-bike share. Relative to the control group, a greater proportion of participants in each of the three intervention groups used a Beryl bike during the study period. Figure 5 shows the differences in the proportions are quite large, ranging from 10.1 to 16.3% greater than the control group. However, a Chi-square test of homogeneity revealed no statistically significant difference in the uptake of Beryl bikes between the control group and the three intervention groups: $X^2(df = 3, N = 151) = 3.353, p = 0.340$. The data was further explored by combining intervention groups in different configurations to boost sample sizes (e.g., combining groups C and D to compare with the control group), but again, no statistically significant

differences were found (Fisher's exact tests⁴). This lack of statistical significance is likely due to the low statistical power of relatively small sample sizes in each intervention group. The implications of small sample sizes when conducting behavior change intervention studies is considered in the Discussion.

The visioning tool intervention had a broader focus than providing free Beryl bike credits, as it encouraged participants to consider multiple ways they could travel more sustainably, not only shared e-bikes. The visioning tool was presented to residents that were allocated to Groups B and D and they were asked, "Please consider your personal situation...where you live in Cornwall, your job, your family commitments, your transport needs. Then choose the character which you think might be the closest to your situation." Table 8 shows which characters the participants selected; *older couple living in a rural area* and *middle-income parents* were the most common.

After reading the character's story, participants were asked to reflect on whether they found the story relevant to their own lives and travel needs. Figure 6 shows over half (53.4%) believe the story is 'somewhat relevant'. The mean score for perceived relevance was 2.62 which, for comparison, is lower than the study of Scottish residents using these pen portraits, where mean scores ranged from 3.03 to 3.73 (Prosser et al., 2022). A higher mean score represents greater perceived relevance.

Figure 7 shows participants' responses for the extent to which the scenario made them feel they could reduce their car use (the dark blue bars), and whether the story gave them ideas for how they might change how they travel in Cornwall or reduce their need to travel (the light blue bars). The most common response for both questions was 'a little' and this indicates the visioning tool did not have a significant impact on changing travel behaviors. The mean score for reducing car use was 2.00 which is somewhat lower than the study of Scottish residents, where mean scores ranged from 2.50 to 3.13 (Prosser et al., 2022). The mean score for generating ideas about changing travel behavior or reducing the need to travel was 1.77 (this question was not presented to Scottish residents). This low perceived impact could be because the participants did not find the visioning tool useful in terms of presenting novel ideas or highlighting possible lifestyle

4 Fisher's exact tests revealed no statistically significant differences in the uptake of Beryl bikes between: (1) those who received free Beryl bike credits (groups C + D; 36.6%) and the control group (20.5%), difference in proportions = 0.161, $p = 0.095$; (2) those who received the visioning tool (groups B + D; 33.3%) and the control group (20.5%), difference in proportions = 0.128, $p = 0.199$; (3) those who received an intervention of any kind (groups B + C + D; 34.6%) and the control group (20.5%), difference in proportions = 0.141, $p = 0.119$.

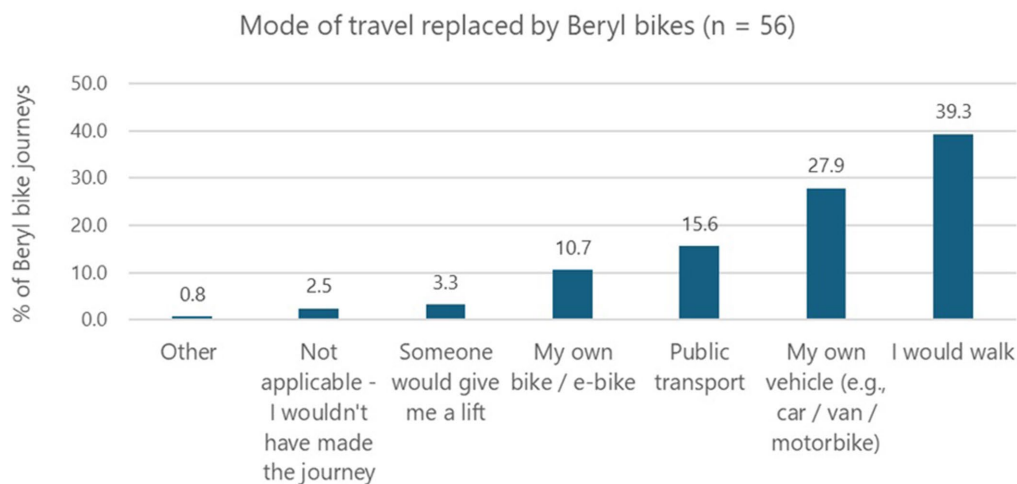


FIGURE 4
Mode of travel replaced by Beryl bike.

TABLE 7 Barriers to the uptake of Beryl bikes.

Barrier	Residents (n = 150)		Council staff (n = 13)	
	Frequency	%	Frequency	%
Personal safety/busy roads/lack of safe cycling routes	111	74.0	8	61.5
Cost of using Beryl bikes	82	54.7	8	61.5
Location of parking bays	56	37.3	7	53.8
Lack of cycling confidence or competence	56	37.3	3	23.1
Long distances/steep hills	51	34.0	2	15.4
Lack of availability of bikes in parking bays	37	24.7	6	46.2
Lack of awareness about Beryl bikes	35	23.3	2	15.4
Beryl bike reliability/battery charge	16	10.7	1	7.7
Beryl bike design/comfort	6	4.0	2	15.4

benefits of reducing car use. However, it could also reflect the structural barriers identified in Study 1, such as limited active travel infrastructure and public transport services, which constrain participants' capacity to reduce their car use irrespective of whether they wish to.

4 Discussion

The discussion consists of two sections; the first considers the use of e-bike share in rural areas and the efficacy of the two interventions in encouraging mode shift, and the second examines some practical and analytical challenges for conducting behavior change interventions in real-world settings.

4.1 Use of e-bike share in rural settings

4.1.1 Perceptions of e-bike share—research aim 1

The participants in this study were broadly positive about Beryl bikes. They perceive a range of practical benefits such as reducing concern around bike theft and avoiding parking difficulties, and this

is consistent with previous research (Teixeira et al., 2023; Bartling, 2023). Co-benefits such as providing an opportunity for physical exercise, improving mental health, and reducing personal carbon footprint have received less attention in previous studies, aside from the CoMoUK annual survey (2022). Interestingly, participants in this Cornwall study and the CoMoUK survey ranked these co-benefits almost as highly as the practical benefits. This suggests e-bike share is viewed not only as a functional or convenient mode of travel, but also as a way of improving personal health and supporting the societal goal of tackling climate change. This 'stacking' of benefits can potentially tip the balance when one attribute, in this case the perceived high cost of using the shared e-bikes, is viewed less favorably.

Another interesting finding was that people living in rural areas and those on lower incomes tend to rank e-bike share attributes higher than people living in urban areas or on higher incomes. For example, rural residents believe that e-bike share would enable them to avoid traffic congestion and parking difficulties, which could reflect negative experiences of driving their car into busy town centers in Cornwall. Those on low incomes see Beryl bikes as an opportunity to use their car less, which could indicate concern about the rising cost of fuel. This variation in perceptions highlights that individual factors can affect the

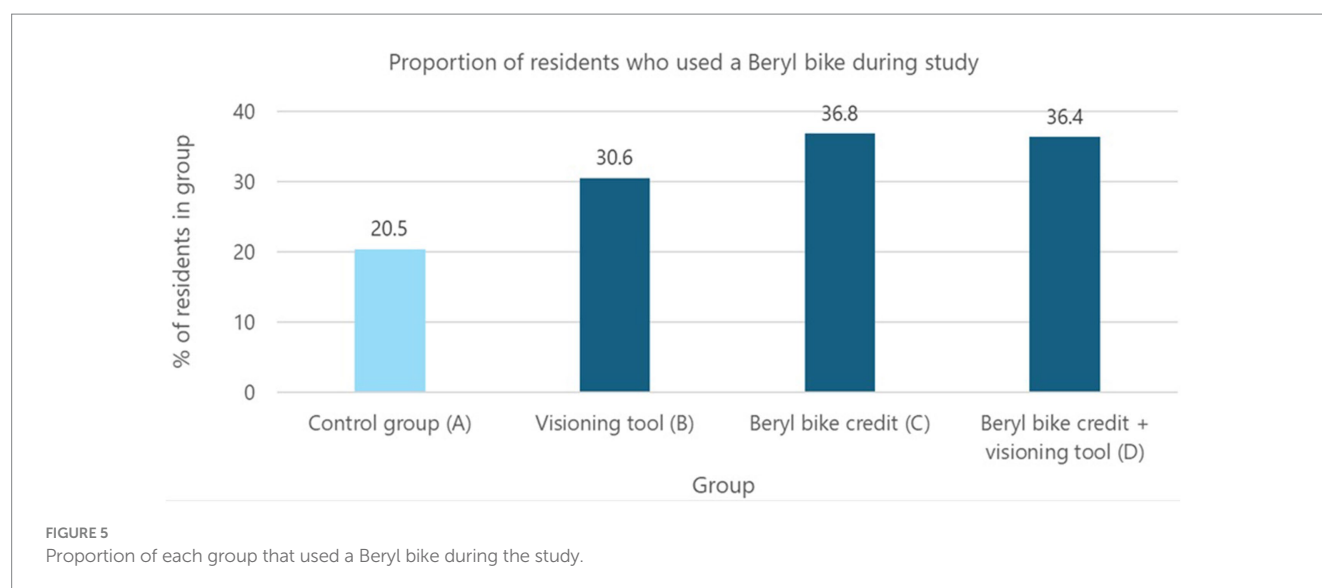


TABLE 8 'Pen portrait' characters selected by recipients of the visioning tool.

Pen portrait characters	Residents (from Groups B & D)	
	Frequency ^a	%
An older couple living in a rural area	21	33.9
Middle-income parents	20	32.3
A young adult living in an urban area	15	24.2
A small business owner	4	6.5
A single parent on lower income	2	3.2
A young adult who uses a wheelchair	0	0.0

^aDue to missing data for the questions which evaluated the pen portraits tool, the number of participants is slightly lower: $n = 62$ (rather than the 69 participants in Groups B & D that completed the remaining data collection activities in this study).

adoption of e-bike share (Barbour et al., 2019; Fukushige et al., 2021). Viewing these findings through a technology adoption theoretical lens, individual factors (e.g., income) and contextual factors (e.g., living in a rural area) are two key determinants that can influence the uptake of an innovation such as a new mode of travel (Straub, 2009; Whittle and Whitmarsh, 2022). Overall, these results indicate a positive potential for the roll out of e-bike share in rural areas.

4.1.2 How e-bike share is used in Cornwall—research aim 2

The participants' journey distances of 2.06–3.21 km per journey are comparable with those identified in previous e-bike share studies (Fukushige et al., 2021; Zhou et al., 2023). This affirms that e-bike share is primarily used for short journeys, irrespective of whether in an urban or rural context. For journey purposes, leisure or exercise and commuting were the most commonly reported journey purposes in this study. This is broadly similar to previous studies (Guidon et al., 2019; CoMoUK, 2022), although participants in this Cornwall study reported higher levels of leisure or exercise journeys. This could be because many were trying e-bike share for the first time and so chose to use it for casual or informal activities initially, as opposed to a necessary journey to work. In terms of mode shift, walking and using a car were the most commonly substituted travel modes. These findings are comparable with evidence of mode shift identified in

other studies, although shared e-bike substitution for public transport is more prominent in areas with high population densities (Fukushige et al., 2021; Bieliński et al., 2021). Some participants combined e-bike share with other travel modes, whereby a Beryl bike is used for the segment of the journey within the town (i.e., the first or last mile). This finding is of particular interest to Cornwall Council, as reducing traffic congestion in towns has societal benefits such as reduced journey times and lower levels of air pollution. Beryl had positioned some of their docking stations near existing park and (bus) ride hubs, in the hope of enabling 'park and e-bike ride' as a multimodal travel option.

4.1.3 Mode shift emission reduction—research aim 3

This study found shifting from single occupancy car to a shared e-bike results in a considerable emission saving of 96–626 g CO₂e per journey, and this reflects the much lower emission intensity of e-bike share compared to ICE vehicles (Brand et al., 2022; Zhou et al., 2023; Li et al., 2023). However, significant emission reduction at the individual level is contingent on how frequently a pro-environmental behavior is performed (Nielsen et al., 2021). For daily travel behaviors, this means regularly choosing e-bike share (or another sustainable mode) over car for work, shopping, and leisure journeys.

The annual emission reduction due to mode shift in this study was modest, only 1.1–13.6 kg CO₂e per person per year. Comparing

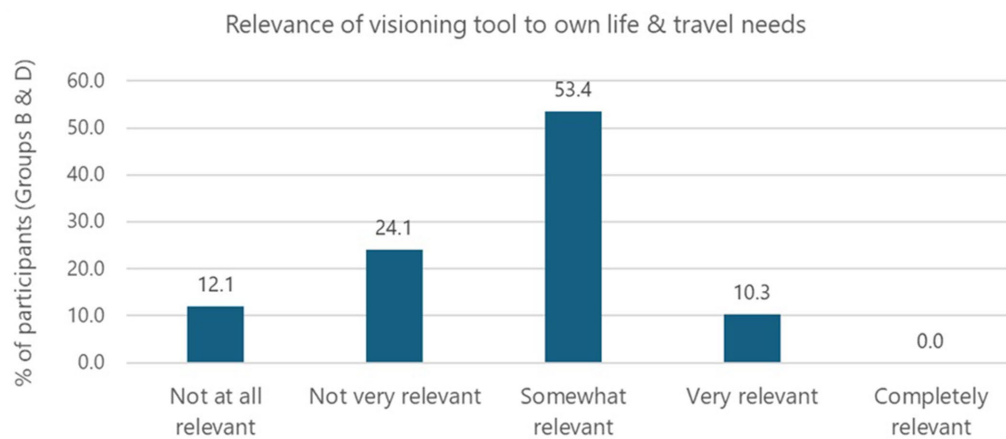


FIGURE 6
Perceived relevance of the visioning tool to participants' lives and travel needs.

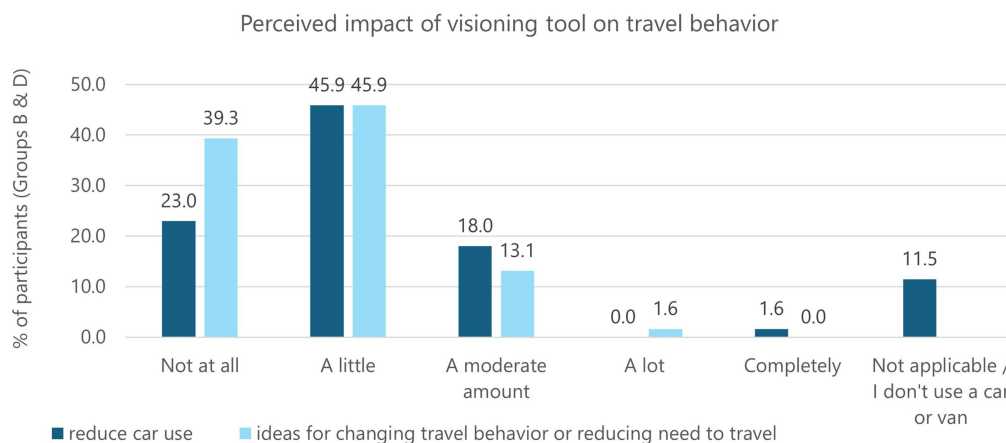


FIGURE 7
Perceived impact of the visioning tool on participants' travel behaviors.

this finding with other studies, [CoMoUK \(2022\)](#) estimates mode shift emission savings to be 71 kg CO₂e per person per year (for bike share and e-bike share users combined), whereas a study of private e-bike users found a much higher reduction of 272–394 kg CO₂e per person per year ([Winslott Hiselius and Svensson, 2017](#)). Although the e-bike journey distances in these two studies are comparable with this Cornwall study, the combined distance of multiple e-bike journeys over a week far exceeds the combined distance of only one or two e-bike journeys a week for the Cornwall participants. These large differences in annual emission reduction are therefore attributed to the relative infrequency of Beryl bike journeys made by the participants in this study, and that many journeys substituted for walking rather than car use. This infrequency of journeys should be viewed in the context that most participants were trying Beryl bikes for the first time and so using e-bike share was not yet embedded in their daily travel behavior. The uptake of bike/e-bike share in the UK and elsewhere would indicate that, for many people, using e-bike share does become habitual and a regularly used travel option ([Galatoulas et al., 2020](#); [CoMoUK, 2024](#)).

The challenge is therefore twofold: how to design interventions which ensure the choice of a sustainable travel mode becomes routine or habitual, and how to target these innovations at frequent car users who have the capacity to shift modes for some of their journeys. Habitual behavior is elicited by specific cues in stable and recurrent performance contexts, such as commuting to work or going food shopping ([Verplanken and Whitmarsh, 2021](#)). Interventions which aim to break existing habits (e.g., car use) should be associated with a repeated activity, such as traveling to work, and be continued for a sufficiently long duration to allow the formation of new habits (e.g., using e-bike share). Moreover, the sustainable mode should be reliable, attractive and flexible so that it may become the default choice ([Powell and James, 2023](#)). A co-benefits framing could be used to target particular social groups, such as frequent car users, and for specific journey purposes (e.g., commuting).

4.1.4 Effectiveness of the behavior change interventions—research aim 4

There was a relatively large increase in the uptake of Beryl bikes during this study, particularly among Cornwall Council employees. Residents and Council staff indicated a strong interest in reducing car

travel and both groups reported positive perceptions of e-bike share attributes, which suggests the participants are interested in exploring more sustainable ways to travel. A particularly encouraging finding was that Beryl bikes were effective at re-engaging non-cyclists; hiring an e-bike encouraged one in three residents to try cycling again after a break. Moreover, the opportunity to try an e-bike before deciding whether to buy one was the highest ranked attribute in this study, and this may be especially important for those who have not cycled for a long period but are interested in trying it again. These findings align with key insights from technology adoption theory, that the compatibility of an innovation with an individual's needs and/or lifestyle is a strong predictor of adoption (Straub, 2009; Whittle and Whitmarsh, 2022). The focus groups revealed another dimension of compatibility, that the assisted power of e-bikes could counteract personal barriers to using active modes such as health difficulties or low fitness levels, as well as some of the physical barriers such as the steep hills and long journey distances that typify travel in many rural areas. While some people will readily choose active modes for the perceived health and wellbeing benefits described in Study 1, others may be deterred by these personal and physical barriers. Engaging these 'harder to reach' social groups and providing mode shift options that are feasible and accessible to them is crucial for achieving equitable, low-carbon travel goals. This study indicates that e-bike share has an important role in making active travel more inclusive, in addition to the health and climate benefits (Fukushige et al., 2021; CoMoUK, 2022).

Despite these positive findings, the results on the efficacy of the two behavior change interventions are mixed. The primary measure of success of the interventions was the adoption of Beryl bikes. The observed differences between the control group and the intervention groups are relatively large, but not sufficiently large enough to produce statistically significant results. This would suggest a potential Type II error (i.e., not detecting a difference when one actually exists), although this is very difficult to ascertain. We can cautiously infer the interventions had a role in encouraging *some* participants to try e-bike share. A more definite finding is that the 'free Beryl bike credits' intervention was more effective in influencing the behavior of Council employees than residents, albeit with a much smaller sample size. This suggests the allocation of free credits may be more effective at motivating adoption of e-bike share among groups of individuals who make similar, frequent journeys (i.e., commuting or work-related travel), than for groups with more heterogeneous journey destinations. This finding aligns with previous studies on e-bike adoption (Ton and Duives, 2021; Julio and Monzon, 2022). Moreover, large organizations have existing communication channels and managers who can influence behaviors and lead by example.

The second intervention was the pen portraits tool for encouraging people to consider how they could reduce car use in their daily lives. Over half of the participants believed the narrative was 'somewhat relevant' to their lives and travel needs. This finding indicates that presenting narratives of low-carbon travel and the potential co-benefits of reducing car use resonates with some people, but not all. The pen portraits visioning tool was developed by Prosser et al. (2022) and, to date, this is the only other study to have applied it. The lower mean scores for perceived relevance and reducing car use would suggest the tool was less effective at motivating behavior change among Cornwall residents than Scottish residents. This might be explained by the structural barriers to active travel in Cornwall identified in the focus groups. Although Scotland and Cornwall are comparable in that a large proportion of residents live in rural areas,

Scotland also has large cities with well-developed active travel and public transport infrastructures. This highlights that the local context of where an intervention is implemented can be a significant determinant of its effectiveness. The importance of context in shaping perceptions was identified in other studies which used a personas-based approach (Cherry et al., 2022, 2024).

4.2 Conducting interventions in real-world settings

The second part of the discussion focuses on the core question of this collection, 'How Do Behavior Science Interventions to Reduce Environmental Impacts Work in The Real World?'. Intervention studies conducted in real-world settings are much needed in the sustainable travel context (Graham-Rowe et al., 2011; Okraszewska et al., 2024), and are important for several reasons. They aim to demonstrate what works, but also what does not, potentially saving expenditure of public money on ineffective large-scale programs. Interventions applied in the context of daily lives can reveal unanticipated barriers to changing behaviors, and whether those barriers primarily relate to personal or structural constraints, which may become apparent only from practical experience (Grilli and Curtis, 2021). They can also reveal specific situations where the behavior change is easier or more difficult to implement, or which social groups found the intervention most useful or compatible with their existing routines. Variation among individuals in terms of their habits or their ability to adopt a particular low-carbon behavior can significantly affect the efficacy of the intervention (Nielsen et al., 2021; Whitmarsh et al., 2021). Finally, the study findings can be used as a tool for engaging people in future behavior change initiatives, by highlighting tangible benefits which the participants experienced that others may be able to relate to their own lives. Experiential findings are therefore more informative than reported perceptions of how an intervention *could* change behaviors in a hypothetical scenario.

4.2.1 The importance of partnerships and co-design

One observation from this study and previous collaborative projects is that forming partnerships with key stakeholders and target groups is an important enabler for effective behavior change interventions (Mitev et al., 2023). This project entailed a collaboration with Cornwall Council, a unitary local authority, and Beryl, the shared e-bike provider. These organizations supported various aspects of the design and implementation of the study. For instance, they used their communication channels to recruit participants, they supplied the credits to use the Beryl bikes, and they provided access to anonymized travel data for the participants' shared e-bike journeys. This partnership therefore considerably increased the scope and ambition of this intervention study, which mutually benefits all partners. Moreover, engaging in a co-design process ensures the intervention aligns with the partners' priorities and provides the empirical data they need to create effective policies or programs for motivating behavior change. This study was also grounded in Cornwall residents' needs and concerns, as elicited through the initial focus group stage. This ensured the intervention design targeted key drivers and barriers of modal shift, tailored to the unique (rural) context of Cornwall. Stakeholders such as local authorities and private sector service

providers have the capacity to rapidly scale up successful interventions, with the potential to significantly reduce environmental impacts, as well as provide individual and societal co-benefits such as improved health. Strong partnerships and shared learnings from previous pilots are more likely to lead to scaling up, or indeed the trialing of other behavior change interventions. Finally, interventions delivered through partnerships provide replicable examples which can be adapted and implemented in comparable settings and locations elsewhere.

4.2.2 Dropout rates and the cost of conducting intervention studies

One challenge of conducting longitudinal intervention studies in real-world settings is the risk of a high participant dropout rate. In this study, the dropout rate was 24% for residents and 48% for Council staff, despite generous incentivization and weekly email contact from the researcher to encourage completion of data collection activities (see [Supplementary material](#)—attrition rate over the intervention period). This high dropout rate is by no means unusual; attrition of 30–70% has been identified in previous longitudinal studies ([de Leeuw and Lugtig, 2014](#); [Verfuert and Sanderson Bellamy, 2022](#)). The main consequence of a high dropout rate is a small sample size, which can lead to low statistical power despite relatively large observed differences between the intervention groups, as in this study. Thus, interventions may appear to be effective, but the lack of statistical significance does not support making strong assertions of their efficacy to project partners such as local authorities. Moreover, negative results are less likely to be published in academic journals (known as ‘positive publication bias’) and this can lead to unnecessary duplication of research, or a distortion of meta-analysis findings ([Mlinarić et al., 2017](#); [Andrews and Kasy, 2019](#)).

One approach to mitigating the impact of participant dropout is to use statistical methods to handle missing data, such as imputation ([Yang and Maxwell, 2014](#); [de Leeuw and Lugtig, 2014](#)). However, substituting missing values can introduce additional sources of bias and therefore requires clear justification regarding the choice of imputation method ([Ren et al., 2023](#)). Another solution is to increase the number of participants to provide a larger sample size, accounting for the anticipated dropout. This solution would also allow us to control for variables known to influence outcome variables (e.g., income) in our analysis, something we were unable to do due to the small sample size. However, this solution encounters a further challenge, because longitudinal behavior change interventions can be expensive to conduct. This intervention study (excluding the initial focus group study and the intervention study with Council staff⁵) cost £3,775 in research participation incentives and £4,000 for the Beryl bike credits. This total of £7,775 does not include researcher or project partner time for co-designing and promoting the study, collecting and analyzing the data, and producing research outputs. Extrapolating from the observed differences between the intervention groups in this study, and assuming an identical

dropout rate of 24%, an initial sample of $n = 577$ would be required to produce a statistically significant difference between the control group and intervention groups C and D.⁶ For this increased sample size, the intervention study would cost £26,196 (excluding researcher time). This cost would be prohibitive for many research projects, except those that are particularly well-funded. This ultimately raises a question of which measures should be used to determine if an intervention has proven successful, given that many local authorities, third sector climate organizations, and universities face funding constraints. A greater reliance on qualitative findings which report participants’ and service providers’ views on the positive and negative impacts of the intervention is one possible solution.

4.3 Limitations

This study had several limitations. The implications of participant dropout have been described above. Further limitations include a potential self-selection bias in the samples of residents and Council workforce. For residents, one of the inclusion criteria specified on the recruitment material was to have an interest in active modes of travel, and so this sample does not include those who have no such interest. Similarly, the Council employee sample may not be representative of the wider Council workforce, as these individuals chose to register for the promotion to receive free Beryl bike credits and so have a discernible interest in active travel. There is no claim that the two samples are representative of the wider populations of all Cornwall residents and Council staff, but it is hoped these samples would reflect the views and travel behaviors of people in Cornwall who are interested in using active modes. There is also a potential self-selection bias in terms of who chooses to participate in a research project, which often leads to an overrepresentation of women in the sample, as in this study. An additional potential bias relates to the use of Council communication channels for recruitment, as not all residents will have signed up to receive Council newsletters or regularly check the Council’s website and social media. Those who are less engaged in Council activities or less familiar with using digital platforms would therefore be unaware of the opportunity to take part. We also cannot rule out the possibility of social desirability bias or demand characteristics in the pen portrait intervention (i.e., reporting a more favorable impact of the intervention on their behavior to align with the study aims). Moreover, it was not possible to link observed data on participants’ use of Beryl bikes with the reported

⁵ The Council staff Beryl bike intervention study cost a further £740, but this amount was not included in this calculation as the staff intervention differs from the resident intervention in terms of its research design.

⁶ These calculations were made using the ClinCalc (<https://clincalc.com/stats/samplesize.aspx>), assuming (1) a dropout rate of 24%, (2) identical proportions between the control group and each intervention group, and (3) a dichotomous dependent variable (i.e., Beryl bike adoption or not). The probability of a Type I error was set at 0.05 (i.e., finding a difference when a difference does not exist) and the probability of a Type II error was set at 0.2 (i.e., not detecting a difference when one actually exists). Given the pen portraits only intervention was less effective at encouraging uptake of Beryl bikes, an even larger initial sample would be required to produce a statistically significant difference between the control group and intervention group B.

data from the surveys and travel diaries, due to Beryl's data protection protocols. Beryl data was therefore aggregated and anonymized which, although still useful, increases the uncertainty range of the emission reduction calculations. The timing of the intervention study, conducted in May–July, may have affected the findings. The interventions would likely be less successful during winter months, when inclement weather would deter some people from using active modes. Suggestions for improving the study design include repeating the intervention during the winter and conducting a follow-up data collection activity to ascertain if the altered travel behaviors have continued after the intervention has finished.

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 humans were approved by the Psychology Research Ethics Committee, University of Bath (references: 22-127; 23-079). The studies were conducted in accordance with the local legislation and institutional requirements. The 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

MW: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. LW: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This work was supported

by the ESRC Centre for Climate Change and Social Transformations (CAST); ES/S012257/1.

Acknowledgments

Annayah M.B. Prosser, Dan Thorman, Kaloyan Mitev, Amiera Sawas and Lorraine Whitmarsh developed the 'pen portraits' visioning tool that was adapted and tested as one of the behavior change interventions in this study (Prosser et al., 2022). Cornwall Council supported the study co-design, the recruitment of research participants, and the provision of Beryl bike credits. Beryl provided anonymized travel data relating to participants' shared e-bike journey frequency and distance.

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.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2025.1569176/full#supplementary-material>

References

- Allen, R., Bennett, H., Cooper, C., and Haggard, P. (2023). Moving on: greener travel for the UK [project report]. London, U.K.: Green Alliance.
- Andrews, I., and Kasy, M. (2019). Identification of and correction for publication bias. *Am. Econ. Rev.* 109, 2766–2794. doi: 10.1257/aer.20180310
- Barbour, N., Zhang, Y., and Mannering, F. (2019). A statistical analysis of bike sharing usage and its potential as an auto-trip substitute. *J. Transp. Health* 12, 253–262. doi: 10.1016/j.jth.2019.02.004
- Bartling, H. (2023). Bike share and user motivation: exploring trip substitution choices among bike share users in a North American city. *Int. J. Sustain. Transp.* 17, 845–854. doi: 10.1080/15568318.2022.2113577
- Biehl, A., Ermagun, A., and Stathopoulos, A. (2019). Utilizing multi-stage behavior change theory to model the process of bike share adoption. *Transp. Policy* 77, 30–45. doi: 10.1016/j.tranpol.2019.02.001
- Bieliński, T., Kwapisz, A., and Ważna, A. (2021). Electric bike-sharing services mode substitution for driving, public transit, and cycling. *Transp. Res. Part D: Transp. Environ.* 96:102883. doi: 10.1016/j.trd.2021.102883
- Brand, C., Dekker, H., and Behrendt, F. (2022). "Chapter eleven - cycling, climate change and air pollution" in *Advances in transport policy and planning*. eds. E. Heinen and T. Götschi, vol. 10 (Cambridge, MA; San Diego; Oxford; London: Elsevier's), 235–264.
- Braun, V., and Clarke, V. (2006). Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 77–101. doi: 10.1191/1478088706qp0630a
- Braunholtz-Speight, T., McLachlan, C., and Barton, H. (2023). International round Table: Accelerating climate mitigation at city level. Available online at: <https://cast.ac.uk/wp-content/uploads/2023/10/CAST-report-international-round-table-accelerating-climate-mitigation-at-city-level.pdf-2.pdf> (Accessed January 10, 2025).

- Bucher, D., Buffat, R., Froemelt, A., and Raubal, M. (2019). Energy and greenhouse gas emission reduction potentials resulting from different commuter electric bicycle adoption scenarios in Switzerland. *Renew. Sust. Energ. Rev.* 114:109298. doi: 10.1016/j.rser.2019.109298
- Bulkeley, H., Broto, V. C., Hodson, M., and Marvin, S. (Eds.) (2011). *Cities and low carbon transitions*, vol. 35. London: Routledge.
- Cherry, C., Thomas, G., Groves, C., Roberts, E., Shirani, F., Henwood, K., et al. (2022). A personas-based approach to deliberating local decarbonisation scenarios: findings and methodological insights. *Energy Res. Soc. Sci.* 87:102455. doi: 10.1016/j.erss.2021.102455
- Cherry, C., Verfuert, C., and Demski, C. (2024). Social visions for a low-carbon future [project report]. Cardiff University: Centre for Climate Change and Social Transformations. Available online at: <https://cast.ac.uk/wp-content/uploads/2024/03/CAST-the-centre-for-climate-change-and-social-transformations-social-visions-for-a-low-carbon-future-report.pdf> (Accessed January 22, 2025).
- CoMoUK (2022). Annual bike share report. Available online at: <https://www.como.org.uk/documents/bike-share-annual-report-uk-2022> (Accessed January 3, 2023).
- CoMoUK (2024). Available online at: <https://www.como.org.uk/shared-bikes/overview-and-benefits> (Accessed January 15, 2024).
- Cornwall Council (2022). Cornwall sector emissions. Available online at: <https://www.cornwall.gov.uk/environment/climate-emergency/the-carbon-neutral-challenge/> (Accessed March 24, 2023).
- de Haas, M., Kroesen, M., Chorus, C., Hoogendoorn-Lanser, S., and Hoogendoorn, S. (2022). E-bike user groups and substitution effects: evidence from longitudinal travel data in the Netherlands. *Transportation* 49, 815–840. doi: 10.1007/s11116-021-10195-3
- de Leeuw, E. D., and Lugtj, P. (2014). “Dropouts in longitudinal surveys” in Wiley STATsREF: Statistics reference online, John Wiley & Sons, Ltd. 1–6.
- Department for Transport (2022). Available online at: <https://www.gov.uk/government/statistics/national-travel-survey-2021/national-travel-survey-2021-household-car-availability-and-trends-in-car-trips> (Accessed January 18, 2024).
- Fishman, E., Washington, S., Haworth, N., and Mazzei, A. (2014). Barriers to bikesharing: an analysis from Melbourne and Brisbane. *J. Transp. Geogr.* 41, 325–337. doi: 10.1016/j.jtrangeo.2014.08.005
- Fukushige, T., Fitch, D. T., and Handy, S. (2021). Factors influencing dock-less E-bike-share mode substitution: evidence from Sacramento, California. *Transp. Res. Part D: Transp. Environ.* 99:102990. doi: 10.1016/j.trd.2021.102990
- Fukushige, T., Fitch, D. T., and Handy, S. (2023). Estimating vehicle-miles traveled reduced from dock-less E-bike-share: evidence from Sacramento, California. *Transp. Res. Part D: Transp. Environ.* 117:103671. doi: 10.1016/j.trd.2023.103671
- Fyhri, A., Heinen, E., Fearnley, N., and Sundfør, H. B. (2017). A push to cycling - exploring the e-bike's role in overcoming barriers to bicycle use with a survey and an intervention study. *Int. J. Sustain. Transp.* 11, 681–695. doi: 10.1080/15568318.2017.1302526
- Galatoulas, N.-F., Genikomsakis, K. N., and Ioakimidis, C. S. (2020). Spatio-temporal trends of E-bike sharing system deployment: a review in Europe, North America and Asia. *Sustainability* 12:4611. doi: 10.3390/su12114611
- Graham-Rowe, E., Skippon, S., Gardner, B., and Abraham, C. (2011). Can we reduce car use and, if so, how? A review of available evidence. *Transp. Res. A Policy Pract.* 45, 401–418. doi: 10.1016/j.tra.2011.02.001
- Grilli, G., and Curtis, J. (2021). Encouraging pro-environmental behaviours: a review of methods and approaches. *Renew. Sust. Energ. Rev.* 135:110039. doi: 10.1016/j.rser.2020.110039
- Guidon, S., Becker, H., Dediu, H., and Axhausen, K. W. (2019). Electric bicycle-sharing: a new competitor in the urban transportation market? An empirical analysis of transaction data. *Transp. Res. Rec.* 2673, 15–26. doi: 10.1177/0361198119836762
- Handy, S. L., and Fitch, D. T. (2022). Can an e-bike share system increase awareness and consideration of e-bikes as a commute mode? Results from a natural experiment. *Int. J. Sustain. Transp.* 16, 34–44. doi: 10.1080/15568318.2020.1847370
- He, Y., Song, Z., Liu, Z., and Sze, N. N. (2019). Factors influencing electric bike share ridership: analysis of Park City, Utah. *Transp. Res. Rec.* 2673, 12–22. doi: 10.1177/0361198119838981
- Hollander, M., and Wolfe, D. A. (1999). *Nonparametric statistical methods*. 2nd Edn. Hoboken, NJ: Wiley.
- Ivanova, D., Barrett, J., Wiedenhofer, D., Macura, B., Callaghan, M., and Creutzig, F. (2020). Quantifying the potential for climate change mitigation of consumption options. *Environ. Res. Lett.* 15:093001. doi: 10.1088/1748-9326/ab8589
- Jones, T., Harms, L., and Heinen, E. (2016). Motives, perceptions and experiences of electric bicycle owners and implications for health, wellbeing and mobility. *J. Transp. Geogr.* 53, 41–49. doi: 10.1016/j.jtrangeo.2016.04.006
- Julio, R., and Monzon, A. (2022). Long term assessment of a successful e-bike-sharing system. Key drivers and impact on travel behaviour. *Case Stud. Transp. Policy* 10, 1299–1313. doi: 10.1016/j.cstp.2022.04.019
- Li, Q., Fuerst, F., and Luca, D. (2023). Do shared E-bikes reduce urban carbon emissions? *J. Transp. Geogr.* 112:103697. doi: 10.1016/j.jtrangeo.2023.103697
- Li, R., Krishna Sinniah, G., and Li, X. (2022). The factors influencing resident's intentions on E-bike sharing usage in China. *Sustain. For.* 14:5013. doi: 10.3390/su14095013
- McQueen, M., MacArthur, J., and Cherry, C. (2020). The E-bike potential: estimating regional e-bike impacts on greenhouse gas emissions. *Transp. Res. Part D: Transp. Environ.* 87:102482. doi: 10.1016/j.trd.2020.102482
- Mees, H. L., Uittenbroek, C. J., Hegger, D. L., and Driessen, P. P. (2019). From citizen participation to government participation: an exploration of the roles of local governments in community initiatives for climate change adaptation in the Netherlands. *Environ. Policy Gov.* 29, 198–208. doi: 10.1002/eet.1847
- Michie, S., Van Stralen, M. M., and West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement. Sci.* 6, 1–12. doi: 10.1186/1748-5908-6-42
- Mitev, K., Player, L., Verfuert, C., Westlake, S., and Whitmarsh, L. (2023). The implications of behavioural science for effective climate policy. Report commissioned by the Climate Change Committee. Available online at: <https://www.theccc.org.uk/publication/the-implications-of-behavioural-science-for-effective-climate-policy-cast/> (Accessed January 25, 2025).
- Mlinarić, A., Horvat, M., and Šupak Smolčić, V. (2017). Dealing with the positive publication bias: why you should really publish your negative results. *Biochem. Med. (Zagreb)* 27:030201. doi: 10.11613/BM.2017.030201
- Moore, B., Verfuert, C., Minas, A. M., Tipping, C., Mander, S., Lorenzoni, I., et al. (2021). Transformations for climate change mitigation: a systematic review of terminology, concepts, and characteristics. *WIREs Climate Change* 12:6. doi: 10.1002/wcc.738
- Moser, C., Blumer, Y., and Hille, S. L. (2018). E-bike trials' potential to promote sustained changes in car owners mobility habits. *Environ. Res. Lett.* 13:044025. doi: 10.1088/1748-9326/aaad73
- Nielsen, K. S., Clayton, S., Stern, P. C., Dietz, T., Capstick, S., and Whitmarsh, L. (2021). How psychology can help limit climate change. *Am. Psychol.* 76, 130–144. doi: 10.1037/amp0000624
- Nisa, C. F., Bélanger, J. J., Schumpe, B. M., and Faller, D. G. (2019). Meta-analysis of randomised controlled trials testing behavioural interventions to promote household action on climate change. *Nat. Commun.* 10:4545. doi: 10.1038/s41467-019-12457-2
- Okraszewska, R., Romanowska, A., Laetsch, D. C., Gobis, A., Reisch, L. A., Kamphuis, C. B., et al. (2024). Interventions reducing car usage: systematic review and meta-analysis. *Transp. Res. Part D: Transp. Environ.* 131:104217. doi: 10.1016/j.trd.2024.104217
- Philips, I., Anable, J., and Chatterton, T. (2022). E-bikes and their capability to reduce car CO₂ emissions. *Transp. Policy* 116, 11–23. doi: 10.1016/j.tranpol.2021.11.019
- Player, L., McGuicken, T., Toy, S., Thorman, D., Wilson, M., and Whitmarsh, L. (2022). Exploring green travel in Cornwall - focus group findings. Internal Cornwall Council report (not publicly available).
- Poortinga, W., and Whitaker, L. (2018). Promoting the use of reusable coffee cups through environmental messaging, the provision of alternatives and financial incentives. *Sustain. For.* 10:873. doi: 10.3390/su10030873
- Powell, D., and James, E. (2023). How public engagement can support reducing car use: a briefing for policy makers and communicators. Available online at: <https://cast.ac.uk/wp-content/uploads/2025/03/CAST-the-centre-for-climate-change-and-social-transformations-briefing-21-how-public-engagement-can-support-reducing-car-use-a-briefing-for-policy-makers-and-communicators.pdf> (Accessed December 7, 2024).
- Prosser, A., Thorman, D., Mitev, K., Sawas, A., and Whitmarsh, L. (2022). Developing an evidence-based toolkit for car reduction [project report]. University of Bath: Centre for Climate Change and Social Transformations. Available online at: https://www.dropbox.com/scl/fi/zc6uoq8kpfdrhngqz288s/CAST-Report-on-Pen-Portraits-Project-Main-report_web.pdf?rlkey=zlkkl7wof5w9phtiq0p4efx12&e=1&dl=0 (Accessed March 7, 2023).
- Ren, L., Wang, T., Sekhari Seklouli, A., Zhang, H., and Bouras, A. (2023). A review on missing values for main challenges and methods. *Inf. Syst.* 119:102268, ISSN 0306-4379. doi: 10.1016/j.is.2023.102268
- Shergold, I., Chatterjee, K., Pantelaki, E., Hiblin, B., and Cairns, S. (2023). Cornwall E-cycle pilot evaluation. Report to Department for Transport. Available online at: <https://www.gov.uk/government/collections/social-research-and-evaluation#cyclling-wheeling-and-walking> (Accessed November 26, 2023).
- Straub, E. T. (2009). Understanding technology adoption: theory and future directions for informal learning. *Rev. Educ. Res.* 79, 625–649. doi: 10.3102/0034654308325896
- Teixeira, J. F., Silva, C., and Moura e Sá, F. (2023). Factors influencing modal shift to bike sharing: evidence from a travel survey conducted during COVID-19. *J. Transp. Geogr.* 111:103651. doi: 10.1016/j.jtrangeo.2023.103651
- Thomas, A. Devon County Council (2019). Lessons learnt from the first fully electric bike share scheme in the UK – A case study of Exeter's co-bikes. Available online at: <https://tps.org.uk/public/downloads/FqIRG/Alex%20Thomas%20TPM%202019%20Best%20Paper-%20Lessons%20learnt%20from%20the%20first%20fully%20electric%20bike%20share%20scheme%20in%20the%20UK.pdf> (Accessed February 8, 2023).

- Ton, D., and Duives, D. (2021). Understanding long-term changes in commuter mode use of a pilot featuring free e-bike trials. *Transp. Policy* 105, 134–144. doi: 10.1016/j.tranpol.2021.03.010
- Toy, S., Whitmarsh, L., Mitev, K., Gan, Y. S., Player, L., McGuicken, T., et al. (2023). Motivating a low-carbon workforce - insights from Cornwall Council. <https://cast.ac.uk/wp-content/uploads/2023/10/the-centre-for-climate-change-and-social-transformations-CAST-briefing-18-motivating-low-carbon-behaviours-in-the-workplace-insights-from-cornwall-council-3.pdf.pdf> (Accessed February 6, 2024).
- UK Health Security Agency (2023). Available online at: <https://assets.publishing.service.gov.uk/media/6570a68b7469300012488948/HECC-report-2023-chapter-4-outdoor-air-quality.pdf> (Accessed November 10, 2024).
- Verfuert, C., Demski, C., Whitmarsh, L., Brauholtz-Speight, T., Cherry, C., David, J., et al. (2024). Catalysts of change: people at the heart of climate transformations. Key messages from five years of social science research on climate change. London: Centre for Climate Change and Social Transformations. Available online at: <https://cast.ac.uk/wp-content/uploads/2025/03/cast-the-centre-for-climate-change-and-social-transformations-key-messages-from-five-years-of-social-science-research-on-climate-change-report-1.pdf>
- Verfuert, C., and Sanderson Bellamy, A. (2022). Accessible veg: a pilot project exploring the barriers and benefits to CSA memberships for food-insecure households [project report]. Cardiff University. Available online at: <https://cast.ac.uk/wp-content/uploads/2022/07/Accessible-Veg-for-web-report.pdf> (Accessed November 17, 2024).
- Verplanken, B., and Whitmarsh, L. (2021). Habit and climate change. *Curr. Opin. Behav. Sci.* 42, 42–46. doi: 10.1016/j.cobeha.2021.02.020
- Whitmarsh, L., and Frost, S. (2024). The public's pragmatic attitude to transport and what it means for achieving net zero. *IPPR Prog. Rev.* 31, 208–213. doi: 10.1111/newe.12403
- Whitmarsh, L., Poortinga, W., and Capstick, S. (2021). Behaviour change to address climate change. *Curr. Opin. Psychol.* 42, 76–81. doi: 10.1016/j.copsyc.2021.04.002
- Whittle, C., and Whitmarsh, L. (2022). “Choosing the electric car” in Electrifying mobility: realising a sustainable future for the Car. Transport and sustainability. eds. G. Parkhurst and W. Clayton, vol. 15 (Bingley: Emerald Publishing Limited), 97–115.
- Wilson, C., Kerr, L., Sprei, F., Vrain, E., and Wilson, M. (2020). Potential climate benefits of digital consumer innovations. *Annu. Rev. Environ. Resour.* 45, 113–144. doi: 10.1146/annurev-environ-012320-082424
- Wilson, M., and Whitmarsh, L. (2023). Cornwall council behaviour change and engagement programme – survey of residents. CAST report for Cornwall council [project report]. Centre for Climate Change and Social Transformations: University of Bath. Available online at: <https://cast.ac.uk/wp-content/uploads/2025/03/CAST-cornwall-council-behaviour-change-and-engagement-programme-survey-of-residents-report-2023.pdf>
- Winslott Hiselius, L., and Svensson, Å. (2017). E-bike use in Sweden – CO₂ effects due to modal change and municipal promotion strategies. *J. Clean. Prod.* 141, 818–824. doi: 10.1016/j.jclepro.2016.09.141
- Winters, M., Hosford, K., and Javaheri, S. (2019). Who are the ‘super-users’ of public bike share? An analysis of public bike share members in Vancouver, BC. *Prev. Med. Rep.* 15:100946. doi: 10.1016/j.pmedr.2019.100946
- Wolstenholme, E., Poortinga, W., and Whitmarsh, L. (2020). Two birds, one stone: the effectiveness of health and environmental messages to reduce meat consumption and encourage pro-environmental behavioral spillover. *Front. Psychol.* 11:577111. doi: 10.3389/fpsyg.2020.577111
- Yang, M., and Maxwell, S. E. (2014). Treatment effects in randomized longitudinal trials with different types of nonignorable dropout. *Psychol. Methods* 19, 188–210. doi: 10.1037/a0033804
- Zhou, Y., Yu, Y., Wang, Y., He, B., and Yang, L. (2023). Mode substitution and carbon emission impacts of electric bike sharing systems. *Sustain. Cities Soc.* 89:104312. doi: 10.1016/j.scs.2022.104312

Frontiers in Psychology

Paving the way for a greater understanding of human behavior

The most cited journal in its field, exploring psychological sciences - from clinical research to cognitive science, from imaging studies to human factors, and from animal cognition to social psychology.

Discover the latest Research Topics

[See more →](#)

Frontiers

Avenue du Tribunal-Fédéral 34
1005 Lausanne, Switzerland
frontiersin.org

Contact us

+41 (0)21 510 17 00
frontiersin.org/about/contact

