EXPERIMENTAL APPROACHES TO BODY IMAGE, REPRESENTATION AND PERCEPTION

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EXPERIMENTAL APPROACHES TO BODY IMAGE, REPRESENTATION AND PERCEPTION

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EDITORIAL
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Editorial: Experimental Approaches to Body Image, Representation and Perception

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Editorial on the Research Topic

Experimental Approaches to Body Image, Representation and Perception

The study of mental representations of bodies stretches back to at least 1905 when French neurologist Pierre Bonnier used the word *aschematie* to refer to a loss of awareness of parts of the body (Bonnier, 1905/2009). Credit is often also given to another neurologist—Englishman Sir Henry Head—whose definition of body schema remains influential to this day (Head et al., 1920). While early studies such as these concentrated on anomalies of body perception and experience following brain injury or amputation, the importance of a multidisciplinary approach was soon realized. Although the classic work of Schilder may be best remembered for its enduring definition of body image ("the picture of our own body which we form in our mind…"), it is also significant for recognizing the importance of sociocultural and psychological considerations alongside the dominant neurological approach of the time (Schilder, 1935/1950). Since then, a broad variety of academics have endeavored to define, measure, and understand this complex and multidimensional construct. The diversity of studies in the current Research Topic reflects this interdisciplinary approach. First, this is demonstrated by the participating journals and sections. Four journals and seven unique sections were involved: Frontiers in Psychology (sections devoted to Cognition, Health Psychology, Cognitive Science, and Psychology for Clinical Settings); Frontiers in Nutrition (Eating Behavior); Frontiers in Neuroscience (Perception Science), and Frontiers in Psychiatry (Psychopathology). The nationality of the groups of authors demonstrates further diversity. In all, 83 contributing authors were based in 15 different nations across five continents. The breadth of participant groups, methods, and topics further demonstrate the multifaceted nature of contemporary research on body image, representation, and perception.

The articles in this Research Topic can be grouped into several overlapping themes. A number of articles are concerned with establishing effective and rigorous systems of measurement for the various aspects of behavior connected with body image disturbance. Korn et al. employ the conjoint analysis (CA) method to measure fear of weight gain, while Legenbauer et al. introduce the Body Image Approach Test (BIAT): a behavioral assessment task for Body Avoidance and Body Checking. Meanwhile, Alexi et al. describe an assessment of the use of synthetic (computer-generated) body stimuli in measuring body size estimation, replicating the serial dependence effect that they previously demonstrated with photos of human bodies. D'Amour and Harris present a novel method of measuring body size estimation at various viewpoint angles using a psychophysical staircase procedure. In particular, their technique purports to measure the brain's representation of the participant's own body.

The issue of perception and representation is the focus of the Research Topic's only Opinion article (Brooks et al.). This article observes the paradox that the same terminology (body size overestimation) is often used to describe opposite patterns of results by scientists with clinical vs. perceptual psychology backgrounds (particularly those perceptual psychologists that use the adaptation paradigm). Consideration of the assumptions of these sub-disciplines and the type of representations that they believe to be distorted can explain this paradox. The adaptation paradigm, which exposes participants to extreme bodies to cause a bias in size and shape judgements for subsequently seen bodies, is applied in several papers. Ambroziak et al. present a study investigating the locus of the adaptation effect, i.e., whether it affects the perception of the experimental stimuli or the stored representation with which these are compared. Brooks et al. and Gould-Fensom et al. employ this paradigm in investigating the neural representation of body adiposity for different genders or ethnicities, respectively. Brooks et al. demonstrated that body size aftereffects do not transfer completely between male and female bodies, suggesting that the neural populations responsible for body size estimation are somewhat selective for gender. However, Gould-Fensom et al. showed complete transfer of the effect between the bodies of Australians of European descent and Malaysians of Asian descent, suggesting that these neurons are not selective for ethnicity. In addition, this paper reminds us of the importance of including non-WEIRD populations in research on body image and chimes with recent evidence that adaptation effects themselves are not culturally or racially bounded, with ethnically diverse samples in low-media contexts still showing typical aftereffects from viewing high or low weight bodies (Boothroyd et al., 2020). In the same spirit, Thornborrow et al. present a cross-cultural study on body image in relation to muscularity for men in the UK, Uganda, and Nicaragua. Despite similarities in the social pressures to attain such bodies, including exposure to muscular bodies in the media, this study demonstrates differences in the bodies considered to be ideal in these cultures. The majority of research on body ideals concentrates on adiposity, usually using women as participants and female bodies as stimuli. Although muscularity is subject to the same kinds of adaptation effects as adiposity (e.g., Sturman et al., 2017; Brooks et al., 2020; Jacques et al., 2021), these results are a reminder that the nuances of the "ideal" may vary in different ways and may be focused on different body composition dimensions for men and women (Brierley et al., 2016).

Exposure is also a feature of the approach taken by Verfaillie and Daems, who demonstrate that long-term priming confers a reaction time advantage for the discrimination of anatomically possible vs. impossible postures/poses. This advantage generalizes across identity but is dependent on viewpoint angle. D'Argenio et al. also look at the perception of posture, finding that dynamic poses give rise to a perception of increased masculinity/decreased femininity. Ding et al. also look at posture and the event-related potentials caused by bodily expressions of emotions, particularly fear, concluding that emotional changes are processed around 210–260 ms after stimulus onset.

The perception of body posture is tested further by Axelsson et al., who ask whether the superior performance previously demonstrated for upright (compared to inverted) bodies is influenced by the presence of faces when visible. This "inversion effect" is also shown by Nazareth et al., for brief (17 ms) stimuli, when asked to identify human (vs. non-human) body stimuli, and is thought to indicate holistic processing for upright, but not for inverted stimuli. Although, Axelson et al. demonstrate body inversion effects even when faces are not visible, these effects increase when faces are present, suggesting a significant influence of faces on holistic processing for bodies. Ritter et al. also investigate the perception of faces, specifically the presence of an inversion effect for those diagnosed with Body Dysmorphic Disorder (BDD) compared with healthy controls. Although the BDD group were hypothesized to be less holistic in their processing of face stimuli, suggesting a reduced inversion effect, these participants showed no such abnormalities. Face perception is again central to Shi et al., who highlight the facial appearance dissatisfaction of those scheduled to undergo orthognathic (jaw) surgery to address a visible difference.

The link between attention and either the perceptual or attitudinal aspects of body image has been a topic of broad interest in recent years (Cho and Lee, 2013; Lang et al., 2014; Moussally et al., 2016; Stephen et al., 2016, 2018, 2019; Dondzilo et al., 2017, 2018; Berrisford-Thompson et al., 2021). This interest is represented in the current issue by several investigations. Cass et al. use a visual search task to investigate attention as a function of observer body size, demonstrating biases toward bodies matching the observer's own in terms of BMI. Meanwhile, Kim et al.'s approach involves eye movement recording to establish the effects of observing thin-ideal images on restrained eaters' attention to pictures of food. In particular, restrained eaters who scored highly on neuroticism showed increased vigilance for food. Engel et al. use a dot probe task to investigate the possibility that attentional training may redirect participants' tendencies to focus on positive or negative parts of their own bodies. As attentional biases to positive/negative body parts were not clear at baseline, abolition of those biases was not possible. However, it remains to be seen whether an intervention such as this might be effective amongst those with more significant body image concerns (e.g., those diagnosed with eating disorders).

Interventions to improve the attitudinal aspects of body image are the subject of several additional articles in this Research Topic. Kosinski reports a pilot study of an evaluative conditioning app for mobile phones. While healthy subjects showed a promising decrease in body dissatisfaction and drive for thinness alongside an increase in self-esteem, this was no greater in the evaluative conditioning group than in the control condition. In contrast, a dissonance-based eating disorder intervention changed implicit attitudes toward thinness—at least for some participants—in the study by Kant et al. Just as Thornborrow et al. above found differences between populations in how bodies were idealized, this study emphasizes the importance of considering subgroups within populations; there were differences between heterosexual and non-heterosexual women in terms of both baseline scores and the effects of the intervention. To date, the vast majority of work in interventions around body perception and body image has concentrated on younger (typically heterosexual) women in urban and high-income populations. In that context, Sánchez-Cabrero et al. make an important step in further broadening the diversity of the literature by demonstrating the effectiveness of a body dissatisfaction intervention—the IMAGINA program—for a frequently overlooked group: older people. For all the elegance and rigor of basic science investigations, of which there are many in this collection, these translational studies are a reminder of the eventual goal of increasing our understanding of the underlying mechanisms of body image—to make people's lives better. Furthermore, that mission must include the full range of those affected by the appearance pressures to which our distorted perceptual experience gives rise.

As Cash and Smolak (2011) commented: "body image transcends a singular experience. It is complex and multidimensional. It is gendered. It is ethnic and cultural. It is age dependent." Encompassing both perceptual and attitudinal aspects of body image, the experimental studies in this Research Topic bear out these observations and demonstrate still more aspects of this fascinating construct, demonstrating considerable potential for further growth. It is hard to dispute that over the last century, the study of body image has seen extraordinary development both in breadth and depth, compared to its humble neurological beginnings. Further expansion over the next century seems inevitable, and with this in mind we invite you to submit your research for our next Frontiers Research Topic on body image, currently planned for 2121.

AUTHOR CONTRIBUTIONS

KB wrote the original draft. LB, JB, and IS contributed important written material, edited the manuscript, and approved the final draft. All authors contributed to the article and approved the submitted version.

REFERENCES

Berrisford-Thompson, J., Sayers, S., Bell, J., Dondzilo, L., and Kennedy, B. L. (2021). Blinded by bodies: elevated eating disorder symptomatology is associated with increased attentional priority for thin bodies. *Body Image* 39, 237–247. doi: 10.1016/j.bodyim.2021.09.003

Bonnier, P. (1905/2009). Asomatognosia P. Bonnier. L'aschématie. Revue Neurol 1905; 13:605-9. *Epilepsy Behav.* 16, 401–403. doi: 10.1016/j.yebeh.2009.09.020

Boothroyd, L. G., Jucker, J. L., Thornborrow, T., Barton, R. A., Burt, D. M., Evans, E. H., et al. (2020). Television consumption drives perceptions of female body attractiveness in a population undergoing technological transition. *J. Pers. Soc. Psychol.* 119, 839–860. doi: 10.1037/pspi0000224

Brierley, M. E., Brooks, K. R., Mond, J., Stevenson, R. J., and Stephen, I. D. (2016). The body and the beautiful: health, attractiveness and body composition in men's and women's bodies. *PLoS One* 11:e0156722. doi: 10.1371/journal.pone.0156722

Brooks, K. R., Keen, E., Sturman, D., Mond, J., Stevenson, R. J., and Stephen, I. D. (2020). Muscle and fat aftereffects and the role of gender: implications for body image disturbance. *Br. J. Psychol.* 111, 742–761. doi: 10.1111/bjop.12439

Cash, T. F., and Smolak, L. (2011). "Understanding body images: historical and contemporary perspectives," in *Body Image: A Handbook of Science, Practice, and Prevention, 2nd Edn.*, eds. T. F. Cash, and L. Smolak (New York, NY: The Guilford Press), 3–11.

Cho, A., and Lee, J. H. (2013). Body dissatisfaction levels and gender differences in attentional biases toward idealized bodies. *Body Image* 10, 95–102. doi: 10.1016/j.bodyim.2012.09.005

Dondzilo, L., Rieger, E., Palermo, R., and Bell, J. (2018). The causal role of selective attention for thin-ideal images on negative affect and rumination. *J. Behav. Ther. Exp. Psychiatry* 61, 128–133. doi: 10.1016/j.jbtep.2018.07.006

Dondzilo, L., Rieger, E., Palermo, R., Byrne, S., and Bell, J. (2017). The mediating role of rumination in the relation between attentional bias towards thin female bodies and eating disorder symptomatology. *PLoS One* 12:e0177870. doi: 10.1371/journal.pone.0177870

Head, H., Rivers, W. H. R., Holmes, G., Sherren, J., Thompson, T., and Riddoch, G. (1920). *Studies in Neurology, Vol. 2*. London: H. Frowde; Hodder and Stoughton, Ltd.

Jacques, K., Evans, E., and Boothroyd, L. (2021). Experimental manipulation of muscularity preferences through visual diet and associative learning. *PLoS One* 16:e0255403. doi: 10.1371/journal.pone.0255403

Lang, K., Lopez, C., Stahl, D., Tchanturia, K., and Treasure, J. (2014). Central coherence in eating disorders: an updated systematic review and meta-analysis. *World J. Biol. Psychiatry* 15, 586–598. doi: 10.3109/15622975.2014.909606

Moussally, J. M., Brosch, T., and Van der Linden, M. (2016). Time course of attentional biases toward body shapes: the impact of body dissatisfaction. *Body Image* 19, 159–168. doi: 10.1016/j.bodyim.2016.09.006

Schilder, P. (1935/1950). *The Image and Appearance of the Human Body: Studies in the Constructive Energies of the Psyche*. New York, NY: International Universities Press.

Stephen, I. D., Bickersteth, C., Mond, J., Stevenson, R. J., and Brooks, K. R. (2016). No effect of featural attention on body size aftereffects. *Front. Psychol.* 7:1223. doi: 10.3389/fpsyg.2016.01223

Stephen, I. D., Hunter, K., Sturman, D., Mond, J., Stevenson, R. J., and Brooks, K. R. (2019). Experimental manipulation of visual attention affects body size adaptation but not body dissatisfaction. *Int. J. Eating Disord.* 52, 79–87. doi: 10.1002/eat.22976

Stephen, I. D., Sturman, D., Stevenson, R. J., Mond, J., and Brooks, K. R. (2018). Visual attention mediates the relationship between body satisfaction and susceptibility to the body size adaptation effect. *PLoS One* 13:e0189855. doi: 10.1371/journal.pone.0189855

Sturman, D., Stephen, I. D., Mond, J., Stevenson, R. J., and Brooks, K. R. (2017). Independent Aftereffects of Fat and Muscle: Implications for neural encoding, body space representation, and body image disturbance. *Sci. Rep.* 7:40392. doi: 10.1038/srep40392

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The Effect of Neuroticism Level on Restrained Eaters' Thinness Fantasy and Attentional Bias for Food

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The aim of this study was to examine the role of restrained eaters' neuroticism level in thinness fantasy and attentional bias for food following exposure to thin-ideal images. Eighty-five female participants were classified into four groups on the basis of their dietary restraint (restrained/unrestrained eaters) and neuroticism level (high/low). They completed self-reports (mood, body dissatisfaction level) on a visual analog scale before and after exposure to thin-ideal images, and then their attentional bias for food was measured using eye-movements. Results indicated that after exposure to thin-ideal images, positive affect was more decreased in restrained eaters with high neuroticism compared to other groups and negative affect was increased in all groups except unrestrained eaters with low neuroticism. Also, restrained eaters with high neuroticism showed a heightened vigilance for food. These findings underscore the role of neuroticism in restrained eaters as a moderating factor of thinness fantasy.

Keywords: restrained eaters, neuroticism, thinness fantasy, attentional bias, body image

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INTRODUCTION

Dietary restraint refers to intentional individual efforts to limit food intake for weight loss or weight control (Herman and Polivy, 1975); the behavior increases risk for onset and maintenance disordered eating such as binge eating and bulimic symptoms (Stice, 2001). Thin-ideal images from mass media are one main risk factor for restrained eating (Anschutz et al., 2011) because restrained eaters are preoccupied with their weight and perceived shape. Images portrayed in the mass media depicting extremely thin and attractive bodies influences restrained eaters, and for some, they set a goal of emulating the thin-ideals portrayed.

When restrained eaters are exposed to thin-ideal images from mass media, these images can sometimes lead to "thinness fantasy" (Mills et al., 2002). Thinness fantasy is cognitive processing that restrained eaters perceive the thin-ideal goal as personally attainable; they believe or fantasize that they can also be thinner in order to achieve the ideal body. This makes them feel thinner, and self-enhancement, such as increased positive affect and body-esteem, and temporarily disinhibit their eating (Mills et al., 2002). For example, restrained eaters who viewed commercial advertisements depicting thin models consumed more food than others who viewed plus size model or product-only advertisements (Warren et al., 2005).

Some replication studies of the impact of thinness fantasy in restrained eaters failed to find evidence of the self-enhancement effect; rather, they showed an increase of negative affect and body dissatisfaction (BD) following exposure to thin-ideal images (Boyce et al., 2013).

Individual differences such as neuroticism and conscientiousness, as a moderating factor between exposure to thin-ideal images and restrained eaters' body images may explain the differential of responses to thin-ideal images of restrained eaters and should be investigated (e.g., Roberts and Good, 2010).

A recent study (Roberts and Good, 2010) posited that neuroticism may be the factor that can explain the inconsistency in the media exposure literature, this is because: only neuroticism listed among the Five-Factor traits was associated with the harmful effect of thin-ideal images. Neuroticism refers to individual differences in emotional lability and adjustment (Costa and McCrae, 1992). When individuals exhibit a high level of neuroticism, they are more likely to be emotionally unstable, experiencing myriad negative affects such as anxiety, hostility, depression, self-consciousness, impulsiveness, and vulnerability (Widiger et al., 2002). Also, they tend to be more reactive to potentially threatening stimuli and prone to avoid them (Rusting, 1998). In the previous study (Roberts and Good, 2010), women with a high level of neuroticism showed a greater decrease of body-esteem and body satisfaction than those with low neuroticism after viewing ideal body images. This is because, in general, exposure to images of exceptionally thin attractive women can be perceived as emotionally threatening to women (Bergstrom et al., 2009) and cause upward social comparison leading to negative affect and low body-esteem. That is, these negative effects appear according to ones' neuroticism level because individuals with high neuroticism are emotionally unstable and experience upward social comparison more frequently than those with low neuroticism (Van der Zee et al., 1999). The results of previous studies, however, do not suggest that women with low levels of neuroticism may experience increased positive affect following exposure to thin-ideal images. Although the relationship between low neuroticism and positive affect in women has not been clarified thus far, given that neuroticism has positively associated to negative affect and BD, it is expected that compared to restrained eaters with high neuroticism, restrained eaters with low neuroticism may experience more self-enhancement effect after viewing thin-ideal images.

Another important effect of neuroticism on restrained eaters is that it plays a role in the pathological development from restrained eating to bulimia (Heaven et al., 2001). The negative affect that restrained eaters experience after viewing thin-ideal images is related to their dieting goal and thus causes extreme restriction of food intake (Boyce et al., 2013), but they usually fail to maintain their control resulting in overeating. Although most previous studies on media images and food intake in restrained eaters have shown that thin-ideal media images are related to restrained eaters' food intake, the results are still unclear. Some research has showed increase of food intake after exposure to media images (Mills et al., 2002; Anschutz et al., 2011), while other research showed a decrease of food intake (Strahan et al., 2007), or non-significant effect (Boyce et al., 2013). One reason for the inconsistent results may be that in previous research, taste tests were used not considering whether they had the tendency to restrict food intake. Also, using direct measures (such as taste tests) are likely to be confounded by reporting bias such as demand characteristics (Mills et al., 2002) and social desirability (Brignell et al., 2009). For this reason, in this study, attentional bias for food was measured using an eye-tracking system. Attentional bias is useful to determine the potential mechanism underpinning the relationship between exposure to thin-ideal images and food consumption.

Attentional bias occurs when emotional salient stimuli are preferentially processed compared to neutral stimuli; it also reflects the cognitive and motivational processing of emotional information (Cisler and Koster, 2010). Early attentional bias (vigilance) reflects an automatic process and speeded detection to a salient stimulus (e.g., threat) or the incentive value of the stimulus while later attentional bias (maintenance or avoidance) reflects a strategic process (Berridge, 2009; Cisler and Koster, 2010). In order to demonstrate attention bias toward food cues, several studies have used the Stroop test or a visual probe task (Dobson and Dozois, 2004; Rofey et al., 2004). However, the results of attention bias were limited in explaining both the initial and later stages of attention, as the Stroop test and the visual probe task were not sufficient in identifying these stages of the attention process. Because these measures based on reaction time which provide only an indirect assessment of attention allocation and do not investigate for shifting of attention between stimuli (Miller and Fillmore, 2010). Using an eye-tracking system, vigilance bias can be measured with the gaze direction and initial fixation duration, and avoidance bias can be measured with gaze duration. A previous study (Hollitt et al., 2010) that measured attentional bias for food in restrained eaters have demonstrated that restrained eaters showed a heightened vigilance for food cues but no differences in disengagement compared to unrestrained eaters. As for restrained eaters, food cues potentially threaten their dietary goal, if restrained eaters' neuroticism is higher, they would show stronger vigilance-avoidance pattern of attention for food.

Overall, the aim of the present study was to investigate whether neuroticism influences mood and BD of restrained eaters following exposure to thin-ideal images and to examine the attentional bias for food in them using an eye-tracker.

MATERIALS AND METHODS

Participants and Screening

Four hundred seventy-five female undergraduate students were recruited, and eighty-five students (M_{age} = 22.81 ± 1.59, M_{BMI} = 20.13 ± 2.04) ultimately participated in this study. Based on the previous research concerning categorizing participants into four groups based on restraint/neuroticism (Kim and Lee, 2016), participants were selected only if they belonged to the upper or lower 25% of the dietary restraint (a score under 39 or over 51) and neuroticism level (a score under 135 or over 149) using Restraint Scale (RS; Herman and Polivy, 1980) and neuroticism items in Revised NEO Personality Inventory (NEO-PI-R; Costa and McCrae, 1992), respectively. They were divided into four groups: restrained eaters with high neuroticism (R-H), restrained eaters with low neuroticism (R-L), unrestrained eaters with high neuroticism (U-H) and unrestrained eaters with low neuroticism (U-L).

Materials and Apparatus

Restraint Scale (RS)

Restraint Scale (Herman and Polivy, 1980) was used for screening participants. RS consists of 15 items measuring dietary restraint behaviors. Participants responded on a 7-point Likert scale ranging from 0 (not at all) to 6 (very much so). The total score ranged from 0 to 90; higher total scores are indicative of dietary restraint. Cronbach's alpha in the present study was 0.92.

Revised NEO Personality Inventory (NEO-PI-R)

The neuroticism subscale of NEO-PI-R (Costa and McCrae, 1992) was also used for screening participants. This scale includes 48 items and measures an individual's neuroticism level. Each item is rated from 1 (not at all) to 5 (very much so). The total score ranges from 48 to 240 with a higher the score indicating a greater level of neuroticism. Cronbach's alpha in the present study was 0.93.

Visual Analog Scale (VAS)

A VAS (Heinberg and Thompson, 1995) was used to assess changes in mood and BD level. The VAS consisted of 100 mm horizontal line (0: not at all; 100: very much).

Thin-Ideal Images

Thirty commercial images depicting a typical ultra-thin female model were collected from fashion magazines. For validation of the thin-ideal images construct, fourteen female undergraduate students, who did not participate in this study, were asked to rate the attractiveness, valence, and arousal of the images on a 7-point Likert scale ranging from 1 (not at all) to 7 (very much so). Based on the results of the students' ratings, fifteen images were chosen that were rated relatively attractive. Each image was presented for 20 s on a monitor screen. All pictures were 150 mm high × 100 mm width.

Free-Viewing Task

A free-viewing task was used to record the participants' eye movements to food pictures. Each trial started with a central fixation cross for 1000 ms and then a picture pair was presented for 2000 ms, followed by a blank screen for 500 ms. Participants were asked to look at the pictures on the screen as if they were watching television and to focus on the fixation cross between trials. A total of 64 trials, including four practice trials and 60 main trials (20 critical and 40 filler trials), were conducted. During the critical trials, each of the 10 highly palatable food pictures (e.g., chips) was paired with a matched control picture (e.g., crayons) as closely as possible for physical properties such as color and visual complexity, and then pretested for palatability, valence, and arousal. In addition, 20 pairs of non-food pictures were selected for filler trials and two pairs for practice trials. The stimuli were displayed side-by-side in pairs on a 21-inch wide monitor screen (1680 × 1050 pixels); all pictures were approximately 75 mm high x 138 mm width. The locations of food and control stimuli were counterbalanced across trials. The participants' eye-movements were recorded by the iView XTM Red-IV Eye Tracking System (SensoMotoric Instruments, Berlin, Germany).

Procedure

At the beginning of the experiment, participants were provided with an informed consent form and asked to report their positive and negative affect and BD level on a VAS. Subsequently, they were exposed to fifteen thin-ideal images for a total of 5 min, rating the attractiveness of each model. They then reported their positive and negative affect and BD level on the VAS again and performed the free-viewing task. Finally, they were debriefed and provided with a $5 gift card.

Data Analysis

Attentional bias scores from the eye-movement data were used in the analyses based on previous study (Werthmann et al., 2011). One participant's data was removed from the eye-movement analysis due to data input error in the eye-tracking system. The direction bias score was calculated for each participant by computing the percentage of initial fixations on the food pictures of all trials on which a first fixation was made to either food or control picture. The bias score greater than 50% reflects a higher proportion of first fixations directed to food cues, that is, vigilance toward food pictures. The initial fixation duration bias score was calculated for each participant by subtracting the mean duration of initial fixations on the control pictures from the mean duration of initial fixations on the food pictures. Positive scores reflect vigilance toward food pictures. The gaze duration bias score was calculated for each participant by subtracting the mean gaze duration on the control pictures from the mean gaze duration on the food pictures. Positive scores reflect attentional maintenance (less avoidance) toward food pictures.

A 2 (restraint status: restrained, unrestrained) × 2 (neuroticism: high, low) Analysis of Variance (ANOVA) was used to analyze participants' characteristics, mood and BD change and the eye-movement data, including gaze direction, initial fixation duration and gaze duration. SPSS 18.0 for Windows was used for the analyses.

RESULTS

Group Characteristics

The mean age and BMI were not significantly different among groups (all *ns*); however, RS and NEO-PI-R scores were significantly different. Regarding the restraint status, R-H group and R-L group had higher scores in RS compared to U-H group and U-L group ($F(1,81) = 420.51$, $p < 0.001$, $\eta_p^2 = 0.84$). Regarding the neuroticism, R-H group and U-H group had higher scores in NEO-PI-R compared to R-L group and U-L group ($F(1,81) = 373.04$, $p < 0.001$, $\eta_p^2 = 0.82$). These group differences for restraint and neuroticism were expected given that participants were allocated to such groups based on their scores on these measures. Data on these variables are displayed in **Table 1**.

TABLE 1 | Mean (*SD*) values for age, BMI, RS, and NEO-PI-R.

	Restrained eaters		Unrestrained eaters	
	High N (n = 21)	Low N (n = 22)	High N (n = 21)	Low N (n = 21)
Age	22.71 (1.65)	23.14 (1.50)	22.29 (1.62)	23.10 (1.55)
BMI	20.70 (1.98)	20.20 (1.52)	19.86 (2.63)	19.78 (1.93)
RS	62.76 (7.27)	63.55 (8.20)	24.29 (9.63)	26.00 (8.90)
NEO-PI-R	167.33 (9.82)	122.45 (9.61)	167.52 (13.27)	122.38 (9.90)

High N, high neuroticism; Low N, low neuroticism; RS, Restraint Scale; NEO-PI-R, revised NEO personality inventory.

Mood and Body Dissatisfaction Changes

Mood and BD level change was calculated for each participant by subtracting the pre-VAS score from the post-VAS score. A positive score reflects the increase of positive affect, negative affect, and BD level following exposure to thin-ideal images. Four participants' data and six participants' data were excluded in positive affect and BD, respectively, because their scores were more than 2 standard deviations greater than the mean of their respective group.

Regarding positive affect, there was a significant interaction between restraint status and neuroticism ($F(1,75) = 4.12$, $p < 0.05$, $\eta_p^2 = 0.05$), and a significant main effect of restraint status ($F(1,75) = 6.68$, $p < 0.05$, $\eta_p^2 = 0.08$). A simple main effects analysis indicated that the R-H group reported a greater decrease of positive affect when compared to the R-L group ($F(1,75) = 5.78$, $p < 0.05$) and U-H group ($F(1,75) = 10.78$, $p < 0.01$).

Regarding negative affect, there was a significant interaction between restraint status and neuroticism ($F(1,81) = 4.10$, $p < 0.05$, $\eta_p^2 = 0.05$). A simple main effects analysis revealed significant differences between the U-L group and U-H group ($F(1,81) = 5.39$, $p < 0.05$) and U-L group and R-L group ($F(1,81) = 5.85$, $p < 0.05$). That is, there were no significant differences in negative affect following exposure to thin-ideal images between individuals with high levels of neuroticism and those with low levels of neuroticism in restrained eaters. Individuals with high neuroticism reported significantly more negative affect than those with low neuroticism in unrestrained eaters.

Lastly, regarding BD, there was a significant main effect of neuroticism ($F(1,77) = 4.51$, $p < 0.05$, $\eta_p^2 = 0.06$): individuals with high levels of neuroticism reported a greater increase of BD level compared to those with low neuroticism.

Eye-Movement Data

The gaze direction and an initial fixation duration bias scores were calculated for vigilance bias. There was a significant interaction between restraint status and neuroticism for the gaze direction bias score ($F(1,80) = 6.37$, $p < 0.05$, $\eta_p^2 = 0.07$). A simple main effects analysis indicated that R-H group and U-L group showed more attentional orienting toward food pictures compared to R-L group ($F(1,80) = 6.60$, $p < 0.05$; $F(1,80) = 6.34$, $p < 0.05$). The results of the gaze direction bias scores are displayed in **Figure 1A**. There were no significant effects for the initial fixation duration bias score.

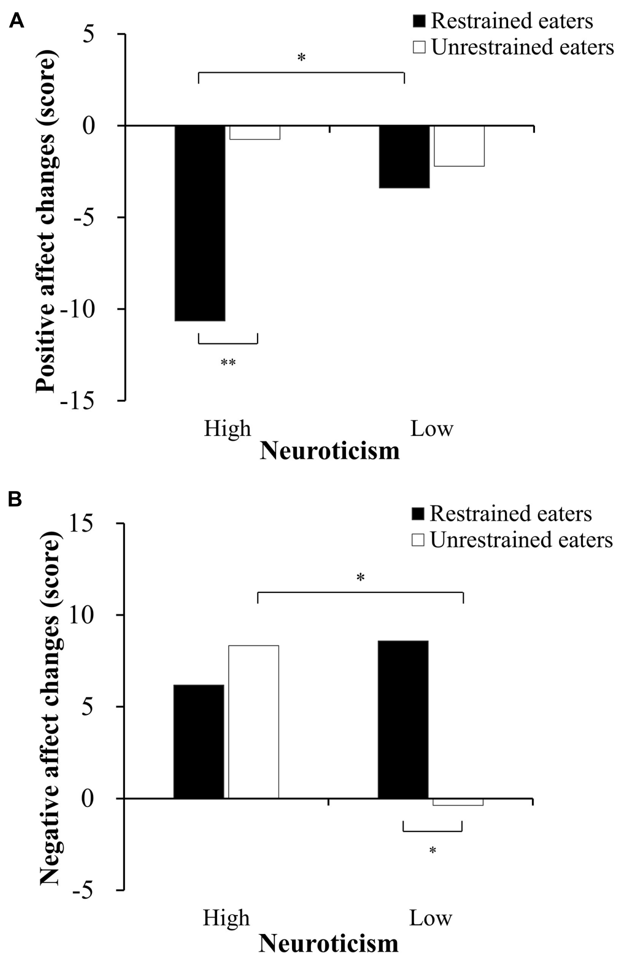

FIGURE 1 | Attentional bias scores for food following exposure to thin-ideal images. Panel **(A)** represents early attentional bias. Panel **(B)** represents later attentional bias. *$p < 0.05$, **$p < 0.01$.

The gaze duration bias score was calculated for avoidance bias. There was a significant main effect of restraint status for the gaze duration bias score ($F(1,80) = 10.51$, $p < 0.01$, $\eta_p^2 = 0.12$). Compared to restrained eaters, unrestrained eaters gazed significantly longer on the food pictures than the control pictures. The results of the gaze duration bias scores are displayed in **Figure 1B**.

DISCUSSION

The present study investigated the effect of neuroticism on restrained eaters' thinness fantasy and attentional bias for food following exposure to thin-ideal images. The changes between pre- and post-VAS scores of mood and BD level revealed that all groups experienced a decrease of positive affect and increase of negative affect and BD, except in the case of unrestrained eaters with low neuroticism in negative affect. In particular, restrained eaters with high neuroticism, when compared to the other groups, showed greatly decreased positive affect following exposure to thin-ideal images, which was consistent with the original study hypothesis. In addition, restrained eaters reported a greater increase of negative affect than unrestrained eaters regardless of their neuroticism level, and individuals with high neuroticism showed a greater increase of BD than individuals with low neuroticism regardless of their restraint status. These results suggest that as one's dietary restraint is more severe and one's neuroticism level is higher, the person becomes more likely to experience deleterious effects from thin-ideal images. Thus, the results of the study seem to be consistent with those of recent studies that, suggest: restrained eaters do not exhibit the self-enhancement effect from thin-ideal images (e.g., Boyce et al., 2013) compared with previous research on restrained eaters' thinness fantasy (e.g., Mills et al., 2002). Especially, this also supports the concept that neuroticism moderates the harmful effect of thin-ideal images in women (Roberts and Good, 2010).

The self-enhancement effect of restrained eaters was not found in the present study. Rather, all restrained eaters showed a decrease of positive affect and increase of negative affect and BD. One possible reason for this is that an individual's neuroticism, which is susceptible to negative emotions, may not be fully responsible for the increase of positive affect after viewing thin-ideal images in restrained eaters. That is, although neuroticism screening items used in this study measured participants' level of emotional instability, the individual's neuroticism level defined as a function of the low score cannot unequivocally represent the person's emotional stability. Therefore, it is possible that when restrained eaters have emotionally stable trait, such as conscientiousness which is associated with confidence and self-efficacy, (Roberts and Good, 2010), thin-ideal images may increase their positive affect. To investigate this potential relationship, further studies should also consider, in addition to measures of emotional instability, countervailing stable personality traits that can promote positive emotions in restrained eaters.

Based on the analysis of eye-movement data, the R-H group and U-L group directed their initial orientations more often toward food in comparison with the R-L group. In addition, overall attentional maintenance toward food was substantially more intense in unrestrained eaters than in restrained eaters. This attentional pattern observed in the R-H group can be interpreted as heightened vigilance-avoidance for food compared to the gaze pattern of other groups. This suggests that when exposed to highly palatable food, the R-H group may have an initial orientation bias toward food cues but avert their eyes from them to avoid the dietary goal threat (Wegner, 1994). These findings support and extend the results of Hollitt et al. (2010) which examined restrained eaters' attentional bias for food using a visual search task. In the study, restrained eaters showed heightened vigilance for food cues, but the visual search task used in the study provided indirect evidence of attentional bias, which is only a discontinuous response prior to behavioral responses (Hermans et al., 1999). The present study, however, demonstrated restrained eaters' early attentional bias and avoidance pattern for food following exposure to thin-ideal images by measuring continuous attentional processing using the eye-tracking system. In particular, the result of early attentional bias for food in restrained eaters suggests that the vigilance bias for food increased along with their neuroticism level.

Overall, the results of the present study indicate that thin-ideal images from media sources can lead to negative mood in restrained eaters leading to vigilance-avoidance pattern for food and BD in individuals with high levels of neuroticism. Thin-ideal images depicting extremely thin and attractive bodies inspire many women, especially restrained eaters, and compel them to set a goal of emulating the thin-ideals that they see on the screen. Generally, this cognitive process induces upward social comparison among the restrained eaters. When women including restrained eaters are exposed to media images of thin-ideal, they compare themselves with the thin-ideal images and focus on areas where they are perceived to be worse. If their goal is higher, it is harder to fulfill, and thus they will have greater self-discrepancy, resulting in increase of negative mood and BD (Krahé and Krause, 2010). According to control theory (Carver and Scheier, 1982) and reinhibition theory (Strauss et al., 1994), the negative mood and BD induced from perceived discrepancy between their present condition and the thin-ideal body triggers goal-related behavior such as restrained eating. In this cognitive process, neuroticism serves as a contributing factor to heightened negative mood and BD because individuals with high levels of neuroticism have more tendencies to make upward comparison than individuals with low levels of neuroticism (Van der Zee et al., 1999; Roberts and Good, 2010). For this reason, it seems that not only R-H group, but also the R-L group and U-H group experienced an increase of negative affect and BD. However, as unrestrained eaters with high neuroticism are not related to dietary restraint, they might not show a vigilance-avoidance pattern of visual attention for food, while restrained eaters with high levels of neuroticism showed the most severe vigilance-avoidance pattern.

Our findings suggest several implications. First, to the best of our knowledge, this is the first study to examine the moderating factor of restrained eaters' thinness fantasy following exposure to thin-ideal images considering their personality traits. Previous studies have shown mixed results regarding restrained eaters' thinness fantasy when compared with unrestrained eaters. In the present study, however, participants were divided into four groups according to both their restraint status and level of neuroticism. Although the self-enhancement effect was not observed in the group, restrained eaters with high levels of neuroticism felt less positive affect and more BD than restrained eaters with low levels of neuroticism. These results highlight the importance of neuroticism as a moderator in the relationship between thin-ideal images and restrained eaters. Second, the results of this study may provide indirect evidence of highly neurotic restrained eaters' goal efforts by identifying a vigilance-avoidance pattern of visual attention for food. Although the gaze duration bias was not significantly different between the R-H group and R-L group, both groups had tendencies to avoid food, and the R-H group showed more intense early vigilance toward food, in line with the results of mood and BD. These results also align with the previous study (Boyce et al., 2013), which suggested that negative affect might encourage restrained eaters' goal-related behaviors. In future studies, it may be necessary to identify how much either negative affect or BD contributes to highly neurotic restrained eaters' goal efforts. Finally, the results from the present study could be helpful in clinical settings for designing intervention of patients with excessive restrained eating. Even if restrained eaters experience self-enhancement following exposure to thin-ideal images, in the long term, it can be a maintenance mechanism of restrained eating by seeking out these images to have positive feelings. Thus, it is fundamentally important to change restrained eaters' ideal body images from unattainable and unrealistic body images to healthy and attractive body images. Additionally, some coping strategies such as emotional regulation or the modification of attentional bias for food should be a consideration for restrained eaters with high neuroticism who are especially susceptible to thin-ideal images. Furthermore, other proper therapies according to weight or shape of restrained eaters or need for health should be considered for future research.

Despite the study's numerous contributions, there are some notable limitations. First, there were no direct measures of thinness fantasy. Although mood and BD level were utilized as proxies to represent the extent of thinness fantasy based on the previous studies (e.g., Mills et al., 2002; Boyce et al., 2013), future studies should focus on identifying a more direct representation of thinness fantasy such as the Thin Fantasy Scale (Talesfore, 2008). Second, the present study used VAS to measure participants' mood and BD changes. Although the data showed some significant differences among groups, the self-report data can be distorted due to social desirability or demand characteristics (Mills et al., 2002; Brignell et al., 2009). Given these acknowledged limitations, future studies may benefit from assessing participants' subjective feelings using indirect methods. Third, this study used a quasi-experimental design rather than an experimental design. A quasi-experimental design is similar to traditional experimental design or randomized controlled trial, but it specifically lacks the factor of random assignment to treatment or control. Thus, in a follow-up study, it would be useful to use an experimental design to compare the effects of different types of images (e.g., thin-ideal versus other body type or neutral images). Finally, this study did not directly investigate the relation between negative affect and attentional bias for food. Although the vigilance-avoidance pattern for food of restrained eaters can be interpreted as their effort to avoid goal threat (Hollitt et al., 2010; Boyce et al., 2013), the results could not conclusively demonstrate the putative relationship. Thus, it would be interesting to investigate how negative affect or BD is related to restrained eaters' dietary goal and how it influences implicit cognitive processing of food or actual eating behavior.

CONCLUSION

In conclusion, the current study demonstrated that restrained eaters with high neuroticism are the most vulnerable to thin-ideal images. They felt negative feelings and showed the most intense vigilance-avoidance pattern for food after exposure to thin-ideal images. These results highlight the importance of clarifying the individual differences moderating the harmful effect of thin-ideal images. Additionally, this study extends our understanding of the role of neuroticism and thinness fantasy in restrained eaters.

AUTHOR'S NOTE

This study is an extended version of work that was presented in the 17th European Conference on Personality.

DATA AVAILABILITY

All datasets generated for this study are included in the manuscript and/or the supplementary files.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of "the Institutional Review Board of Chung-Ang University" with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the "Institutional Review Board of Chung-Ang University."

AUTHOR CONTRIBUTIONS

All authors designed the study, collected the data, interpreted the results, read and corrected the draft versions of the manuscript, and approved the final version. JK drafted the manuscript with supervision of KK and J-HL.

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REFERENCES

Anschutz, D. J., Van Strien, T., and Engels, R. C. (2011). Exposure to slim images in mass media: television commercials as reminders of restriction in restrained eaters. *Health Psychol.* 27, 401–448. doi: 10.1037/0278-6133.27.4.401

Bergstrom, R. L., Neighbors, C., and Malheim, J. E. (2009). Media comparisons and threats to body image: seeking evidence of self-affirmation. *J. Soc. Clin. Psychol.* 28, 264–280. doi: 10.1521/jscp.2009.28.2.264

Berridge, K. C. (2009). 'Liking' and 'wanting' food rewards: brain substrates and roles in eating disorders. *Physiol. Behav.* 97, 537–550. doi: 10.1016/j.physbeh.2009.02.044

Boyce, J. A., Kuijer, R. G., and Gleaves, D. H. (2013). Positive fantasies or negative contrasts: the effect of media body ideals on restrained eaters' mood, weight satisfaction, and food intake. *Body Image* 10, 535–543. doi: 10.1016/j.bodyim.2013.07.002

Brignell, C., Griffiths, T., Bradley, B. P., and Mogg, K. (2009). Attentional and approach biases for pictorial food cues. Influence of external eating. *Appetite* 52, 299–306. doi: 10.1016/j.appet.2008.10.007

Carver, C. S., and Scheier, M. F. (1982). Control theory: a useful conceptual framework for personality, social, clinical and health psychology. *Psychol. Bull.* 92, 111–135. doi: 10.1037//0033-2909.92.1.111

Cisler, J. M., and Koster, E. H. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: an integrative review. *Clin. Psychol. Rev.* 30, 203–216. doi: 10.1016/j.cpr.2009.11.003

Costa, P. T. Jr., and McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) Professional Manual*. Odessa, FL: Psychological Assessment Resources.

Dobson, K. S., and Dozois, D. A. (2004). Attentional biases in eating disorders: a meta-analytic review of stroop performance. *Clin. Psychol. Rev.* 23, 1001–1022. doi: 10.1016/j.cpr.2003.09.004

Heaven, P. C., Mulligan, K., Merrilees, R., Woods, T., and Fairooz, Y. (2001). Neuroticism and conscientiousness as predictors of emotional, external, and restrained eating behaviors. *Int. J. Eat. Disord.* 30, 161–166. doi: 10.1002/eat.1068

Heinberg, L. J., and Thompson, J. K. (1995). Body image and televised images of thinness and attractiveness: a controlled laboratory investigation. *J. Soc. Clin. Psychol.* 14, 325–338. doi: 10.1521/jscp.1995.14.4.325

Herman, C. P., and Polivy, J. (1975). Anxiety, restraint, and eating behavior. *J. Abnorm. Psychol.* 84, 666–672. doi: 10.1037//0021-843x.84.6.666

Herman, C. P., and Polivy, J. (1980). "Restrained eating," in *Obesity*, ed. A. Stunkard (Philadelphia, PA: W. B. Saunders), 208–225.

Hermans, D., Vansteenwegen, D., and Eelen, P. (1999). Eye movement registration as a continuous index of attention deployment: data from a group of spider anxious students. *Cogn. Emot.* 13, 419–434. doi: 10.1080/026999399379249

Hollitt, S., Kemps, E., Tiggemann, M., Smeets, E., and Mills, J. S. (2010). Components of attentional bias for food cues among restrained eaters. *Appetite* 54, 309–313. doi: 10.1016/j.appet.2009.12.005

Kim, J., and Lee, J. H. (2016). The effect of neuroticism level on restrained eaters' self-enhancement and eating behavior following exposure to thin-ideal images. *Korean J. Clin. Psychol.* 35, 195–214. doi: 10.15842/kjcp.2016.35.1.010

Krahé, B., and Krause, C. (2010). Presenting thin media models affects women's choice of diet or normal snacks. *Psychol. Women Q.* 34, 349–355. doi: 10.1111/j.1471-6402.2010.01580.x

Miller, M. A., and Fillmore, M. T. (2010). The effect of image complexity on attentional bias towards alcohol-related images in adult drinkers. *Addiction* 105, 883–890. doi: 10.1111/j.1360-0443.2009.02860.x

Mills, J. S., Polivy, J., Herman, C. P., and Tiggemann, M. (2002). Effects of exposure to thin media images: evidence of self-enhancement among restrained eaters. *Pers. Soc. Psychol. Bull.* 28, 1687–1699. doi: 10.1177/014616702237650

Roberts, A., and Good, E. (2010). Media images and female body dissatisfaction: the moderating effects of the five-factor traits. *Eat. Behav.* 11, 211–216. doi: 10.1016/j.eatbeh.2010.04.002

Rofey, D. L., Corcoran, K. J., and Tran, G. Q. (2004). Bulimic symptoms and mood predict food relevant stroop interference in women with troubled eating patterns. *Eat. Behav.* 5, 35–45. doi: 10.1016/s1471-0153(03)00058-8

Rusting, C. (1998). Personality, mood, and cognitive processing of emotional information: three conceptual frameworks. *Psychol. Bull.* 124, 165–196. doi: 10.1037//0033-2909.124.2.165

Stice, E. (2001). A prospective test of the dual pathway model of bulimic pathology: mediating effects of dieting and negative affect. *J. Abnorm. Psychol.* 110, 124–135. doi: 10.1037//0021-843x.110.1.124

Strahan, E. J., Spencer, S. J., and Zanna, M. P. (2007). Don't take another bite: how sociocultural norms for appearance affect women's eating behavior. *Body Image* 4, 331–342. doi: 10.1016/j.bodyim.2007.06.003

Strauss, J., Doyle, A. E., and Kreipe, R. E. (1994). The paradoxical effect of diet commercials on reinhibition of dietary restraint. *J. Abnorm. Psychol.* 103, 441–444. doi: 10.1037/0021-843x.103.3.441

Talesfore, C. M. (2008). *The Thin Fantasy: An Examination of a Potential Factor in Mass Media's Self-Enhancing Effects on Restrained Eaters*. Ph.D. thesis, University of Hawai'i, Honolulu.

Van der Zee, K. I., Buunnk, B., Sanderman, R., Botke, G., and Van der Bergh, F. (1999). The big five and identification-contrast processes in social comparison in adjustment to cancer treatment. *Eur. J. Personal.* 13, 307–326. doi: 10.1002/(sici)1099-0984(199907/08)13:4<307::aid-per342>3.0.co;2-r

Warren, C. S., Strauss, J., Taska, J. L., and Sullivan, S. J. (2005). Inspiring or dispiriting? The effect of diet commercials on snack food consumption in high school and college-aged women. *Int. J. Eat. Disord.* 37, 266–270. doi: 10.1002/eat.20100

Wegner, D. M. (1994). Ironic processes of mental control. *Psychol. Rev.* 101, 34–52. doi: 10.1037//0033-295x.101.1.34

Werthmann, J., Roefs, A., Nederkoorn, C., Mogg, K., Bradley, B. P., and Jansen, A. (2011). Can(not) take my eyes off it: attention bias for food in overweight participants. *Health Psychol.* 30, 561–569. doi: 10.1037/a0024291

Widiger, T. A., Costa, P. T. Jr., and McCrae, R. R. (2002). "A proposal for Axis II: diagnosing personality disorders using the five-factor model," in *Personality Disorders and the Five-Factor Model of Personality*, 2nd Edn, eds P. T. Costa Jr. and T. A. Widiger (Washington, DC: American Psychological Association), 431–456. doi: 10.1037/10423-025

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Automatic Change Detection of Emotional and Neutral Body Expressions: Evidence From Visual Mismatch Negativity

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Rapidly and effectively detecting emotions in others is an important social skill. Since emotions expressed by the face are relatively easy to fake or hide, we often use body language to gauge the genuine emotional state of others. Recent studies suggest that expression-related visual mismatch negativity (vMMN) reflects the automatic processing of emotional changes in facial expression; however, the automatic processing of changes in body expression has not yet been studied systematically. The current study uses an oddball paradigm where neutral body actions served as standard stimuli, while fearful body expressions and other neutral body actions served as two different deviants to define body-related vMMN, and to compare the mechanisms underlying the processing of emotional changes to neutral postural changes. The results show a more negative vMMN amplitude for fear deviants 210–260 ms after stimulus onset which corresponds with the negativity bias that was obtained on the N190 component. In earlier time windows, the vMMN amplitude following the two types of deviant stimuli are identical. Therefore, we present a two-stage model for processing changes in body posture, where changes in body posture are processed in the first 170–210 ms, but emotional changes in the time window of 210–260 ms.

Keywords: affect, emotional body language, visual mismatch negativity, visual processing, electroencephalography

INTRODUCTION

The environment surrounding humans is constantly changing. In order to survive and adapt to this changing environment, our perceptual system has the important task of probing and collecting information regarding these changes (Czigler and Pató, 2009). The visual system, as the most significant part of the perceptual system for humans, plays a crucial role in detecting changes in environmental information. However, due to the limitations in the capacity of the human brain (Marois and Ivanoff, 2005), the visual system has developed the ability to automatically process the most relevant stimuli first, that is, those which can be either just novel (for instance, the sudden opening of the mouth of an interaction partner) or emotionally relevant (such as the emerging smile on an interaction partner's face) (Kovarski et al., 2017).

The neurophysiological mechanisms of automatic change detection by the visual system have been widely explored in terms of the visual mismatch negativity (vMMN) component of event-related potentials (ERPs) (Kimura et al., 2011; Czigler, 2014). The vMMN is usually obtained in passive oddball paradigms and is defined as activity resulting from the subtraction of activity following standard stimulation from deviant stimulation. Previous studies have obtained effective vMMN activity not only in the change of low-level stimulus features such as color (Czigler et al., 2004; Muller et al., 2012), shape (Maekawa et al., 2005), and motion direction (Pazoalvarez et al., 2015) but also in changes in observed facial expressions of emotion (Susac et al., 2010; Astikainen et al., 2013; Kovarski et al., 2017). This suggests that the neural mechanism related to the processing of the two types of changes (both neutral and emotional) by the visual system can be reflected in vMMN.

The ability to identify changes in emotional expressions is of primary importance in social life (Fujimura and Okanoya, 2013; Chen et al., 2016). Therefore, an emotional facilitation effect has often been reported (Ikeda et al., 2013; Carretié, 2014; Hinojosa et al., 2015). However, only a few studies have directly compared emotional deviancy to neutral deviancy to distinguish the detection of emotional and neutral change (Gayle et al., 2012; Vogel et al., 2015; Kovarski et al., 2017). The study by Vogel et al. (2015) provides direct evidence that emotional (fear) vMMN has advantages over neutral vMMN in terms of latency and amplitude. Another study found that emotional (anger) deviants had a more sustained effect than neutral deviants, even though both deviants showed overlap at the early stage (Kovarski et al., 2017). Furthermore, this result may be explained by another study, which reported that the early difference waves (around 130 ms) reflect the processing of general rule violation, while the later difference waves (around 170 ms) reflect emotional processing (Astikainen et al., 2013). Together, although the detection of emotional deviancy seems to boost vMMN activity, prior to that, there seems to be a stage that just detects deviancy, independent of emotion. However, more research is needed to verify this presumption. Bodily expressions provide an excellent opportunity to do so, as changes in action or emotion lead to a different configuration of the limbs and thus greater changes than in facial expressions (where the position of the eyes, nose, and mouth do not change too much).

Humans express their emotions through various modalities including the voice, the face, and the whole body. Despite the multimodality of emotions, almost all previous studies involving emotion-related vMMN have used facial expressions of emotion as stimulus materials. However, the other important carrier of visual emotional information, body language, has been neglected to a large extent (de Gelder, 2009; Kret et al., 2013). Although previous studies have found that static bodily expressions can be automatically processed, similar to facial expressions (van Heijnsbergen et al., 2007; Gu et al., 2013), the mechanisms of the detection of changes in body expression have not been explored fully. Questions such as whether changes in emotional information contained in body posture can be processed quickly, whether the processing of body expressions is identical to the processing of facial expressions, and whether postural changes are similarly reflected in vMMN as is the case for facial expressions, remain unanswered. Some body postures (such as fear) are signals of approaching danger; preparing for adaptive behavior by rapid and accurate detection of the sudden postural changes in an observed other, is important for survival (de Gelder et al., 2004; de Gelder, 2006, 2009). Research suggests that the processing of body expressions relies on similar visual processing mechanisms as that of facial expressions, both in regard to their timing, as evidenced from electroencephalography (EEG) studies (Stekelenburg and de Gelder, 2004; Meeren et al., 2005; Thierry et al., 2006; Righart and de Gelder, 2007; van Heijnsbergen et al., 2007; Gu et al., 2013), and their location (neural overlap has been demonstrated with fMRI: Giese and Poggio, 2003; Hadjikhani and de Gelder, 2003; de Gelder et al., 2004; Van de Riet et al., 2009; Kret et al., 2011) or both (Meeren et al., 2013). Therefore, we speculated that a change in body posture can be automatically detected and processed, especially when the change reflects a threat signal, and vMMN [expression-related vMMN (EMMN)] could be evoked by this affective processing, in a similar manner as that observed in facial expression studies. In addition, this vMMN activity might have the same distribution as that of vMMN caused by facial expressions.

The N170 is an ERP component that reflects the fast processing of configural information of both faces and bodies (Gliga and Dehaene-Lambertz, 2005). Although body postures can also induce an N170 response, their emotional content does not modulate its amplitude, suggesting it is mainly involved in the structural coding procedure of body expressions (Stekelenburg and de Gelder, 2004; van Heijnsbergen et al., 2007). Another component, the N190, has been considered to be sensitive to both body movements and emotional information as indicated by some previous studies (Borhani et al., 2015, 2016). The component has been widely tested in several studies (Thierry et al., 2006; Righart and de Gelder, 2007; Borhani et al., 2015), and the latency of N190 is often about 50 ms later than N170. We expected that the differences for the two types of change information expressed by the body would be reflected in the N190 component rather than the P1 component, which is sensitive to low-level spatial and physical features of the stimulus (Hillyard and Anllo-Vento, 1998). Therefore, in this study, we selected a body expression without facial information as the stimulus to evoke the N190 component (Thierry et al., 2006), and hypothesized that the N190 amplitude would be enhanced by fear deviants compared with neutral deviants. The present study also attempted to verify body-related vMMN in the occipito-temporal areas, which are usually used for obtaining vMMN in facial studies. On this basis, vMMN evoked by neutral and emotional deviants were compared to explore the specific processing of emotional change detection. If the exploration of emotional changes originates from the simultaneous activation of a general visual change detection mechanism and emotional processing, the neutral and emotional vMMN should partially overlap. Conversely, there may be a special system for emotional change processing.

MATERIALS AND METHODS

Participants

Twenty-eight healthy students participated in this experiment. The EEG data of seven subjects were excluded from the final analysis because of poor behavioral performance (the accuracy rates of task execution were less than 0.8). The final sample consisted of 21 subjects (mean age = 22.38 years, SD = 2.56 years, 11 females). We followed previous studies to base our sample size on. To verify, we performed a power analysis ($f = 0.2$, $\alpha = 0.05$, power = 0.80) by G*Power 3.1.9.3 (Faul et al., 2007, 2009) and found that at least 12 participants were needed to be able to replicate previous studies. Our sample size clearly met this requirement.

All subjects had normal or corrected-to-normal vision and one of them was left-handed. Written informed consent was obtained from each participant after the nature of the experiment had been fully explained. The study was approved by the ethical committee board of the Northwest Normal University.

The participants in this study were engaged in the experimental task and had normal emotion processing abilities, as demonstrated by their high accuracy rates (mean accuracy = 0.914; *SD* = 0.047, range 0.80–0.98).

Stimuli and Procedure

A different group of 30 participants (mean age = 23.37, age range = 22–27 years old) validated the stimulus materials. They were asked to categorize the stimuli in terms of emotional content (choose from angry, fear, happy, and neutral) and to provide an emotional arousal rating (scale 1–7) for each stimulus. For this validation study, 18 body pictures of six different actresses were selected from the BEAST stimulus set (de Gelder and van den Stock, 2011). Based on this validation study, one identity (female) was selected as the final stimulus (that is, the one with the highest accuracy). The photograph showed an implied motion posture without emotional content (right hand on head) and was presented as the standard stimulus (std); another neutral body posture of the same woman (right hand in front of the mouth), in which motion was also implied, was presented as the neutral deviant stimulus, and an implied motion posture expressing emotion (fear) was presented as the fear deviant stimulus (**Figure 1A**) (We have obtained the written informed consent of the model). The accuracy of the std. image was 83% and the mean arousal rating was 2.77. Accuracy of the devNeutral and devFear images was 83 and 97%, respectively, and the mean arousal ratings for the two images were 3.60 and 4.20, respectively.

In the formal experiment, the stimuli were presented in an oddball sequence. The probability of occurrence for the three types of stimuli was as follows: standard stimulus (std) $p = 0.80$; neutral deviant stimulus (devNeutral) $p = 0.10$; and fear deviant stimulus (devFear) $p = 0.10$ (**Figure 1B**).

Participants sat comfortably in an armchair at a distance of 60 cm from a computer monitor. Stimuli were presented and controlled using E-prime software. Each body posture image subtended a visual angle of 1.6° horizontally and 2.6° vertically. Stimulus duration was 150 ms, and the stimulus onset asynchrony (SOA) was randomized between 500 and 700 ms (**Figure 1C**). The whole sequence comprised 1,280 stimuli; thus, our experiment needed around 15 min to display all the images (for similar procedures, see for instance, Kovarski et al., 2017). The subjects were allowed to have a break after they finished 320 trials. As in previous vMMN studies, subjects were asked to perform a concurrent visual task in order to study automatic change detection. They were required to focus on the white fixation cross in the middle of the picture, and press the "k" button as quickly as possible if the cross disappeared. Thus, the target stimuli were the same as the std. images but did not have a white cross, and the probability of occurrence of the target stimuli was $p = 0.05$. Subjects were allowed to respond both during the stimuli presentation and during the blanks after the stimuli, both instances could generate correct responses.

Electroencephalography Recording and Processing

EEG signals were recorded using a 64-channel amplifier ANT Neuro EEGO mounted on an electrode cap according to the 10–20 system. Blinks and eye movements were recorded bipolar from the outer canthi of the eyes (horizontal electrooculogram [EOG]) and from above and below the subject's left eye (vertical EOG). All electrodes were online referenced to the CPz. The impedance of all electrodes was kept below 5 kΩ. The EEG signal was digitized at a sampling rate of 500 Hz.

Subsequent data analyses were carried out off-line using EEGLAB 14.1.2 (Delorme and Makeig, 2004) in the Matlab 9.2.0 development environment (The Mathworks, Natic, MA, USA). The original EEG signals were re-referenced to the common average potential, following which a high pass filter of 0.10 Hz and a low pass filter of 30 Hz were applied to the continuous data. For all three types of stimuli (the target trials were excluded from the analysis), epochs of 600 ms (−100 ms pre-stimulus and 500 ms post-stimulus) were extracted from the continuous EEG signals and were baseline corrected (pre-stimulus activity, from −100 to 0 ms) (van Heijnsbergen et al., 2007; Stefanics et al., 2012). Individual epochs with voltage values exceeding ±50 μV on any channel were rejected from the analysis and ocular artifacts were removed by applying Independent Component Analysis (Delorme and Makeig, 2004) as implemented in EEGLAB. The remaining epochs were averaged separately for each participant and each stimulus type. For each stimulus of interest the average number of artifact-free trials was: 675 ± 127 (std), 89 ± 17 (devFear), and 88 ± 17 (devNeutral).

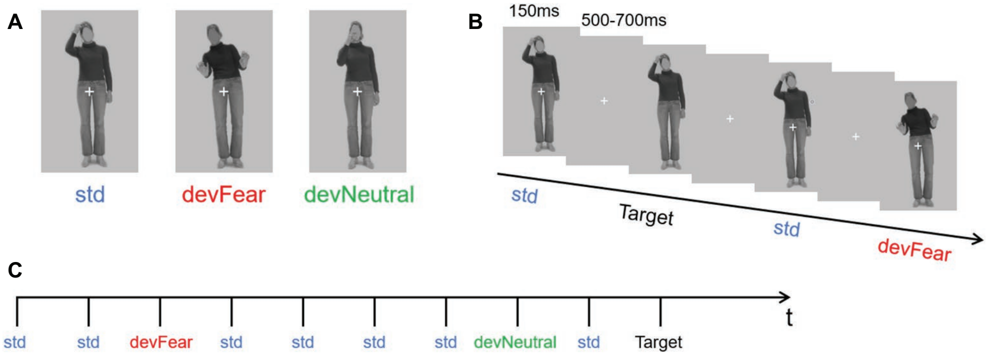

FIGURE 1 | (A) shows the three types of stimuli (neutral standard: std; emotional deviant: devFear; and neutral deviant: devNeutral). **(B)** is a task schematic of the oddball sequence. **(C)** shows the time course of the stimulus presented for 150 ms, followed by the cross on a gray screen displayed for 500–700 ms; SOA = 650–850 ms, and a target stimulus (neutral standard without cross, participants need to press the "k" button when it appears). (Statement: the stimuli used in the picture has been approved for publication by the owner).

Behavioral Data Analysis

Since the task during the experiment was unrelated to the purpose of our study, only the accuracy rate of the target stimulus was calculated, which was used as an indicator of subject's level of engagement in the experiment.

Statistical Analyses of Event-Related Potentials

P1 and N190 components were measured on the ERPs evoked by each stimulus type (std, devNeutral, and devFear). Based on previous findings with regard to the P1 and N190, and combined visual inspection of the grand-average waveforms, we chose a time window of 90–150 ms post stimulus presentation to quantify the mean amplitude of the P1 potential, and a time window of 160–220 ms post stimulus presentation to quantify the mean amplitude of N190 (Thierry et al., 2006; Borhani et al., 2015). In addition, the peak amplitude of P1 reached a maximum positive deflection on electrodes O1 and O2. Therefore, electrodes O1 and O2 were chosen as the regions of interest (ROIs) in the P1 analyses, in accordance with previous studies (Righart and de Gelder, 2007; Kovarski et al., 2017). Furthermore, electrodes P7 and P8 were chosen as the ROIs in the N190 analyses on account of the fact that the peak amplitude of this component reached a maximum negative deflection on these two electrodes and also because it was in line with previous studies (Stekelenburg and de Gelder, 2004; Thierry et al., 2006; Borhani et al., 2016).

Both the P1 and the N190 mean amplitudes were analyzed using a repeated-measures analysis of variance (ANOVA) with deviant-type (devNeutral vs. devFear) × hemisphere (left vs. right) as within-subject factors. The effect sizes were calculated in terms of η_p^2.

Statistical Analyses of MMNs

By subtracting the ERPs of the std. stimuli from ERPs of devFear or devNeutral stimuli, an emotion vMMN (fear vMMN) and a neutral vMMN were respectively created to index brain activity specifically elicited by emotional or neutral automatic change detection. According to the topographical maps of these difference waveforms (**Figure 2**), we selected four ROIs for vMMN amplitude measurements, at left temporal (P7, P5, and TP7), right temporal (P8, P6, and TP8), left occipital (O1, PO3, PO5, and PO7) and right occipital (O2, PO4, PO6, and PO8) electrode clusters. Furthermore, the electrode clusters selected for analyses are marked with black circles in black frames in **Figure 2**. These ROIs are also consistent with previous studies regarding emotion-related vMMN (Stefanics et al., 2012; Kovarski et al., 2017; Yin et al., 2018). Mean vMMN responses were calculated by averaging across electrodes within the ROIs.

Based on a recent study (Kovarski et al., 2017), we tested vMMN responses for each condition (i.e., fear and neutral deviants) by comparing ERP amplitudes to 0, using Student's *t*-test corrected for multiple comparisons (Guthrie and Buchwald, 1991) at each ROIs and each time point (Analysis results are presented in **Supplementary Materials**). This analysis provides preliminary information about the presence of meaningful deflections. And then, visual inspection of the topographical maps (we examined the vMMN topography for every 10 ms intervals between 0 and 500 ms) of these difference waveforms showed larger negativities for deviants relative to standards at occipito-temporal sites in the 170–210 ms intervals for both deviant types. But the fear vMMN is more sustained than the neutral vMMN; it remains activity in the 210–260 ms time window (**Figure 2**). Combine these reasons, two consecutive time windows were selected for the analysis of vMMN: 170–210 ms and 210–260 ms. This time frames setting is also consistent with the recent study, the early vMMNs latency range corresponding to the common neutral and emotional response, and the following latency range was selected to measure differential activity and investigate specific response to emotional deviants (Kovarski et al., 2017). Within these time-windows ANOVAs were performed including deviant-type (devNeutral vs. devFear) × ROI (temporal vs. occipital) × Hemisphere (left vs. right). When necessary, ANOVA results were corrected following the Greenhouse-Geisser procedure and *post hoc* analyses were corrected with a Bonferroni correction.

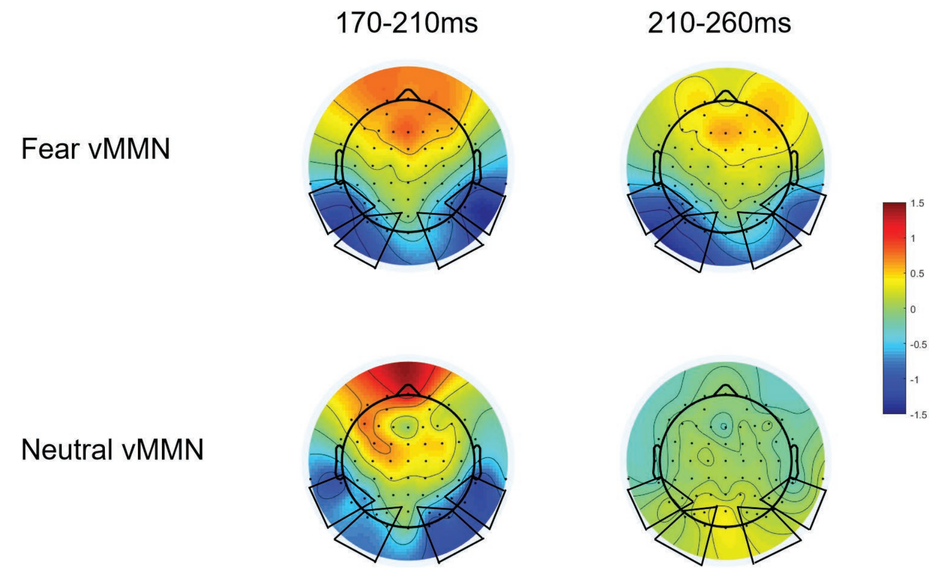

FIGURE 2 | Scalp topographic maps of vMMN (EMMN) components evoked by devFear and devNeutral.

RESULTS

Results of Event-Related Potentials

No main effects were observed for deviant-type (p = 0.51) and hemisphere (p = 0.49) on the P1 amplitude; the deviant-type × hemisphere interaction did not reach significance on this component either (p = 0.13), see **Figure 3**.

The analyses for the N190 amplitude showed a main effect for deviant-type, F (1, 20) = 15.93, p = 0.001, $\eta_p^2 = 0.44$. As expected, the N190 amplitudes were more negative in devFear than in devNeutral. Effects of hemisphere (p = 0.22) or interaction effects (p = 0.65) were not observed, see **Figure 3**.

Results of MMNs

In the 170–210 ms latency range, a main effect of deviant-type was observed [F (1, 20) = 6.72, p = 0.017, η_p^2 = 0.25], with more negative responses following devFear compared to devNeutral, see **Figures 2, 4**. A main effect of ROI was also observed [F (1, 20) = 7.09, p = 0.015, η_p^2 = 0.26], with larger amplitudes over the temporal than the occipital sites. Importantly, a significant interaction between deviant-type and ROI was found [F (1, 20) = 5.17, p = 0.034, η_p^2 = 0.21]. Pairwise comparisons indicated that devFear elicited enhanced vMMN amplitudes compared to devNeutral on the temporal sites (p = 0.004). By contrast, the type of deviant stimulus did not have a significant effect on the occipital sites (p = 0.083), suggesting similar processing of both deviants in this brain region. There was also a significant three-way interaction of deviant-type × ROI × Hemisphere, F (1, 20) = 5.04, p = 0.036, $\eta_p^2 = 0.20$. *Post hoc* comparisons revealed that fear vMMNs were more negative on temporal sites than occipital sites (p = 0.003). These results were significant over right hemisphere electrodes only. No other main effect (hemisphere) or interactions were significant ($ps \geq 0.05$).

In the 210–260 ms latency range, the analysis of the vMMN amplitude showed a main effect of deviant-type [F (1, 20) = 11.23, p = 0.003, η_p^2 = 0.36], which was caused by more negative responses to devFear compared to devNeutral, see **Figures 2, 4**. Moreover, the interaction between deviant-type and Hemisphere was significant [F (1, 20) = 6.07, p = 0.023, η_p^2 = 0.23]. *Post hoc* analysis revealed a larger amplitude over left hemisphere electrodes compared to right hemisphere electrodes for fear vMMN only (p = 0.021). The main effect of the ROI and hemisphere was not significant (p = 0.08; p = 0.11, respectively), and there were no other interactions that were statistically significant ($ps \geq 0.05$).

DISCUSSION

The ability to identify changes in emotional expressions is not just important for understanding others' mental states, but also for avoiding interpersonal conflicts and constructing interpersonal harmony. Although changes in body posture can reveal critical information about emotions, the mechanism behind the processing of these changes has not yet been well explored (Aviezer et al., 2012; for a review, see de Gelder et al., 2010). This is the first study to investigate the automatic processing of changes in observed emotional body language and changes in neutral bodily actions and to test the specificity of the neural mechanism that underlies the processing of emotional deviants during an oddball paradigm. The results first demonstrate a difference between the N190 amplitude in response to emotional compared to neutral deviants. No such difference was observed on the P1. Second, we demonstrate vMMN activity when participants observed changes in both emotional and neutral postures. Third, on several locations

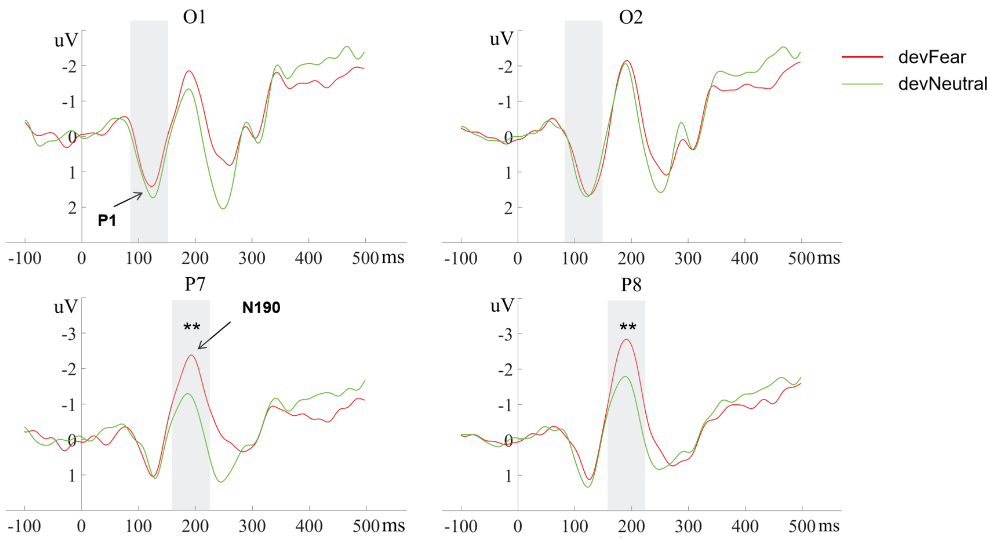

FIGURE 3 | The grand-average ERPs at O1, O2, P7, and P8 evoked by devFear (red line) and devNeutral(green line). **$p < 0.01$. The P1 was equal following fearful as compared to neutral deviants. The shaded area indicates the statistical analysis time window of the P1 and the N170.

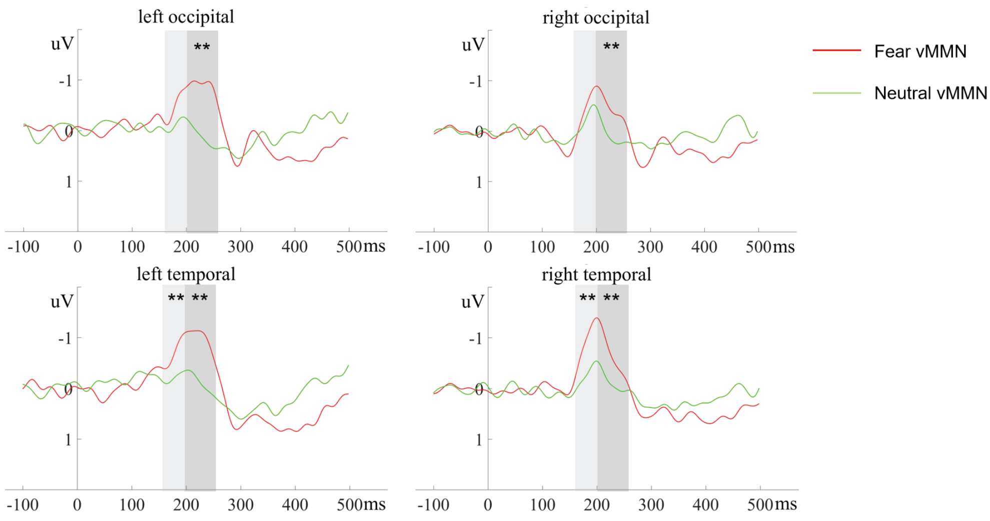

FIGURE 4 | The ERP responses to deviant-minus-standard differential (vMMN) waveforms at different electrode clusters evoked by devFear (red line) and devNeutral (green line). **$p < 0.01$. The shaded area indicates the statistical analysis time windows of early and late vMMN, respectively.

and specifically during the later time windows, the emotion-induced vMMN was more sustained and had a larger amplitude than the vMMN that followed neutral images. These findings are consistent with our hypotheses. In the sections below, we discuss these three core findings in the context of the existing literature and present a novel two stage model of processing changes in body posture.

In the current study, the P1 amplitude was not modulated by emotional information. Consistent with our results, a previous study that used face-body compounds as well as isolated faces and bodies, found that although the P1 did not discriminate between anger and fear expressed in isolated faces and bodies, the amplitude of this component was enhanced for incongruent face-body compounds (Meeren et al., 2005). Another study, which used isolated bodies only, presented somewhat different results; the fearful body expression evoked a larger P1 amplitude than the neutral body expression (van Heijnsbergen et al., 2007). Importantly, a recent vMMN study found more negative P1 responses to deviant fearful compared to standard fearful faces (Stefanics et al., 2012). However, in this latter study, it is important to note that no neutral images were used as was the case in the current study. In the previous study, in one block, fearful facial expressions were presented as frequent standards and happy facial expressions as rare deviants. The standard and deviant emotions were swapped during the second block. Thus, the authors used the exact same emotional faces twice, once as standard and once as deviant stimuli, and hence, the difference in P1 amplitude is not caused by facial emotion information (Stefanics et al., 2012). In fact, we can see that the relative novel (unexpected) stimuli in the above studies caused a larger P1 amplitude (Meeren et al., 2005; van Heijnsbergen et al., 2007; Stefanics et al., 2012). Therefore, combining our results and the existing literature, it can be concluded that the P1 reflects the notification of novel or unexpected stimuli rather than the regulation of emotional information. Thus, the more unique a stimulus is, the more likely it is to boost processing at this stage. To conclude, this component represents an initial filtering function before the automatic processing of body expression information.

Another key finding of our study is the main effect of deviant-type on the N190 amplitude, showing that fear deviants induced a larger N190 amplitude than neutral deviants. This result confirms earlier research and shows that emotional stimuli are prioritized at this stage (Borhani et al., 2015). Importantly, using a different paradigm, that study also found that the N190 was sensitive to both neutral (instrumental actions) and emotion information conveyed by body posture. This is in line with the present study, and indicates that this component is sensitive not only to static neutral and emotional body postures, but also to the changes of non-emotional movement information and emotional information reflected in body posture.

The robust vMMN in the time window of 170–260 ms caused by emotional deviants at the occipital and temporal electrodes, supports our hypothesis about the existence of body expression vMMN, and supplements the research gap with regard to the automatic processing of changes in body posture. Some previous facial expression related vMMN studies found that the time range of vMMN corresponds well to the N170 (Chang et al., 2010; Stefanics et al., 2012), and according to the source analyses of the N170, Stefanics et al. (2012) propose the superior temporal gyrus and sulcus as a potential source of the emotional vMMN response. In the present study, the time window of the vMMN we obtained is consistent with the time window of the N190, so we speculate that body expression related vMMN reflects N190 activity. Then, there is an interesting but unexpected finding that the vMMN obtained in the present study has a shorter duration (90 ms) compared to the facial vMMN obtained in past studies (245 ms, Zhao and Li, 2006; 275 ms, Gayle et al., 2012; 105 ms, Kimura et al., 2012; 320 ms, Stefanics et al., 2012). Although there are no previous studies we can refer to compare the duration of body vMMN, we considered two potential explanations for the shorter duration of the vMMN in our study, compared to the studies using facial expressions. First, the most straightforward explanation is that the duration of body vMMN activity is shorter than the duration of facial vMMN activity. Further research is needed to verify whether the duration we observed is indeed specific for bodily expressions or whether for some other reason the duration in the current study was shorter compared to previous studies.

Another point of consideration is the fact that in contrast to the previous facial expression studies where a neutral, inactive face served as the standard stimulus, we did not use a completely static neutral body posture as the standard stimulus, but instead used another neutral bodily action. Previous research has shown that the brain is in a higher state of activation when observing a body with implied action than when just observing a static body posture (Grèzes et al., 2007; Kret et al., 2011; Borgomaneri et al., 2015). For this reason, if we had used a calm body posture as standard stimulus, we might have gotten a duration of vMMN similar to previous facial expression studies. That is, going from a calm state to an active one might take longer than going from action into another type of action. In real life, emotional expressions almost never emerge out of a completely neutral inactive state, but rather emerge when we are involved in some kind of action. For that reason, we believe that our study has higher ecological validity and this issue is not only relevant for processing bodily expressions but also for expressions from other modalities including the face or even voice.

In the first time window (170–210 ms), both deviants evoked a significantly negative difference waveform (vMMN). Within this time window, the topographic maps of the vMMN responses for fearful and neutral deviants are remarkably similar (**Figure 2**), and there was no significant difference between the amplitude of these two vMMN responses at the occipital electrodes; this may have occurred corresponding to the common neutral and emotional change response as suggested in previous studies (Astikainen et al., 2013; Kovarski et al., 2017). Kovarski et al. (2017) demonstrated similar results regarding facial expressions and inferred that the vMMN evoked by either neutral or emotional deviants is based on a general mechanism of visual change processing. Therefore, they suggested that the exploration of emotional changes involves two different pre-attention systems, that is, a mechanism of visual change detection and an additional mechanism of emotion processing. In fact, an earlier study interpreted the early difference wave as a general rule violation detection, while the later difference wave was interpreted as emotional processing (Astikainen et al., 2013). Furthermore, the enhanced vMMN amplitude following fearful body compared to neutral body expressions obtained from this time window (170–210 ms) on the temporal electrodes, suggesting the potential source of the early general mechanism. As mentioned above, the vMMN we obtained reflects the modulating role of the N190 in the automatic processing of changes in body posture, and previous studies have identified the EBA in temporal cortex as the potential neural basis for the N190 (Thierry et al., 2006). While the EBA, which is connected to the amygdala and the parietal cortex, has been considered as a core region of human body perception, it is mainly responsible for visual processing of the body and is sensitive to emotional (Van de Riet et al., 2009; Downing and Peelen, 2011; van den Stock et al., 2012) and motor (Borgomaneri et al., 2015; Downing and Peelen, 2016) information. Thus, the advantage of the vMMN amplitude at temporal electrode clusters may have revealed the active responses of EBA, while similar responses detected at the occipital electrodes may correspond to the general automatic visual processing of body stimulus changes in the Striate Cortex (V1) or Extrastriate Cortex.

More sustained and stronger vMMN responses evoked by fear deviants in 210–260 ms is consistent with the "negativity bias" reported in previous vMMN studies (anger: Kovarski et al., 2017, sadness: Zhao and Li, 2006; Gayle et al., 2012, and fear: Stefanics et al., 2012). Previous studies have shown that negative emotion takes more resources to process compared to positive or neutral emotion, even when attention is limited by high-load tasks (Srinivasan and Gupta, 2010; Gupta and Déak, 2015; Gupta and Srinivasan, 2015; Gupta et al., 2016). Negative emotions were also found to initially capture and hold attention compared to positive and neutral (Ciesielski et al., 2010; Srinivasan and Gupta, 2011). This may partly explain the current findings. However, other studies that compared positive and negative vMMN did not show this effect (Astikainen and Hietanen, 2009; Astikainen et al., 2013), suggesting that differences in protocols (i.e., concurrent task, paradigm, and stimuli) modulate the emotion-related vMMN (Kovarski et al., 2017). In several previous studies, attention is usually directed toward a task presented in a different sensory modality to prevent attentional processes that might overlap with the vMMN component (Zhao and Li, 2006; Astikainen and Hietanen, 2009; Gayle et al., 2012), and this may be a limitation of present study. Without considering the influence of emotional valence, these studies support the specificity of automatic processing of emotional changes, and our results extend the advantageous effect of this processing of emotional changes to the field of body expression.

Fear vMMN showed differential lateralization patterns between the two time windows. In the early period, vMMN responses to fearful deviants were more negative over right temporal sites, but neutral vMMN did not show similar results. This observation is in support of the "right hemisphere hypothesis", postulating that the right hemisphere is dominant for processing emotions (Borod et al., 1998). Gupta and Raymond (2012) presented a central, irrelevant, expressive (angry, happy, sad, or fearful) or neutral face prior to a letter search task, and found that emotional processing is right hemisphere biased than non-emotional stimuli. Several previous vMMN studies also reported a right-hemisphere lateralization of the emotional vMMN (Gayle et al., 2012; Li et al., 2012; Vogel et al., 2015). Consistent with the above research, the current result confirms that the processing of fearful body change information in this period also has the right hemisphere advantage. By contrast, the hemispheric dominance reversed in the subsequent time window, i.e. increased vMMN amplitudes were observed on the left hemisphere electrode sites for fear deviants within 210–260 ms. This left hemispheric effects may correspond to contextual effects that were observed in an facial related study. This study used face-context compounds stimulus to investigate how the early stages of face processing are affected by emotional scenes, and found that N170 amplitudes were enhanced on the left hemisphere electrode sites when fearful faces were accompanied by fearful scenes rather than happy or neutral scenes (Righart and de Gelder, 2008). The researchers suggested emotions may combine specifically for fear at early stage of encoding. In fact, a large number of vMMN studies have suggested that oddball sequence provides unintentional temporal context (Kimura et al., 2012; Stefanics et al., 2012; Vogel et al., 2015). Therefore, in this processing stage, the fear deviants may be integrated with the background information extracted from the previous stimulus sequence, and the left hemisphere also has the advantage of integrating fear change information. The different activation patterns of hemisphere in the two adjacent vMMN time windows further revealed the different automatic processing stages of body expressions.

In summary, our results about vMMN suggest that emotional and neutral changes in body posture are initially processed by the same automated processing system, and emotional information is then further analyzed. We here propose a two-stage model that is partly based on previous literature (**Figure 5**). In an earlier study, using emotional expressions, Chang et al. (2010) showed two peaks of vMMN that have been interpreted as two different stages reflecting either modulation of the N170 and P250, and this view was echoed by two other emotional expression vMMN studies (Zhao and Li, 2006; Stefanics et al., 2012). Furthermore, two different

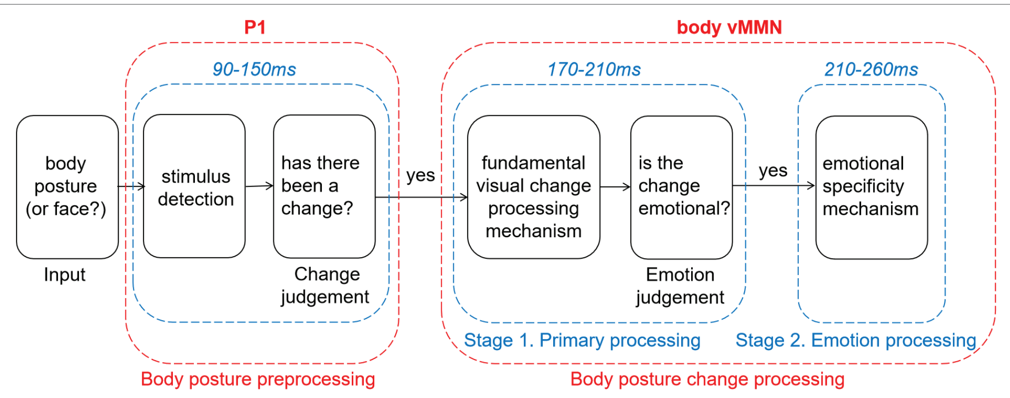

FIGURE 5 | Two-stage model of processing changes in body posture.

stages have been described, reflecting detection and pre-attentional processing in another emotional expression vMMN study (Astikainen and Hietanen, 2009). In line with our results, Kovarski et al. (2017) found similar activity following the neutral and the emotional deviants around the first and second peaks (100–200 ms and 250–350 ms, respectively) and sustained negative activity for angry deviants only in the time windows following the peaks (150–300 ms and 350–480 ms). The authors explain their result as reflecting two distinct preattentional systems: the visual change detection mechanism and an additional emotional processing stage. It provides powerful support for our model and suggests that this model may be applicable to a wider range of emotional carriers. In addition, we have updated this model based on the present study in the following way. First, we added a preprcocessing procedure that always selects novel (unexpected) expressional information into automatic change detection and secondly, we adapted this model to the body N190 activity. Further research is needed to revise and update this model further.

CONCLUSIONS

Before giving the final summary, we want to emphasize the limitation of current statistical method. The statistical data mining in our study is not independent from the main hypothesis well, and should be regarded as an explorative approach. But with limited explanatory power, our study reveals that changes in observed neutral or emotional body postures recruit activity in early automatic processing areas, indexed by vMMN activity, in a slightly different way. It is worth noting that the vMMN evoked by neutral and emotional deviants show two different stages. The first stage is a fundamental visual change processing stage. The second stage is an emotion processing stage (**Figure 5**). These findings are consistent with previous studies of facial expression. That might imply that the detection of emotional changes expressed through the face or body and possibly through other modalities as well, relies on similar brain mechanisms. Further studies need to verify whether this is indeed the case, in the case of a greater methodological rigor.

DATA AVAILABILITY

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of "Ethics of psychological research, The scientific and research Ethics Committee of the School of Psychology, NWNU" with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the "The scientific and research Ethics Committee of the School of Psychology, NWNU."

AUTHOR CONTRIBUTIONS

JL and XD both contributed to conceive and study design. JL and RW performed experiments and collected data. JL and TK analyzed the behavior and ERP data and drafted the manuscript. MK provided critical revisions. MK and JL approved the final version of the manuscript for submission. All authors read and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.01909/full#supplementary-material

SUPPLEMENTARY FIGURES 1–4 | vMMN amplitude and *p*-value for *t*-test of four ROIs ($p < 0.05$). The black boxes are the time windows of effective negative component in these images.

REFERENCES

Astikainen, P., Cong, F., Ristaniemi, T., and Hietanen, J. K. (2013). Event-related potentials to unattended changes in facial expressions: detection of regularity violations or encoding of emotions. *Front. Hum. Neurosci.* 7:557. doi: 10.3389/fnhum.2013.00557

Astikainen, P., and Hietanen, J. K. (2009). Event-related potentials to task-irrelevant changes in facial expressions. *Behav. Brain Funct.* 5:30. doi: 10.1186/1744-9081-5-30

Aviezer, H., Trope, Y., and Todorov, A. (2012). Body cues, not facial expressions, discriminate between intense positive and negative emotions. *Science* 338, 1225–1229. doi: 10.1126/science.1224313

Borgomaneri, S., Vitale, F., Gazzola, V., and Avenanti, A. (2015). Seeing fearful body language rapidly freezes the observer's motor cortex. *Cortex* 65, 232–245. doi: 10.1016/j.cortex.2015.01.014

Borhani, K., Borgomaneri, S., Làdavas, E., and Bertini, C. (2016). The effect of alexithymia on early visual processing of emotional body postures. *Biol. Psychol.* 115, 1–8. doi: 10.1016/j.biopsycho.2015.12.010

Borhani, K., Làdavas, E., Maier, M. E., Avenanti, A., and Bertini, C. (2015). Emotional and movement-related body postures modulate visual processing. *Soc. Cogn. Affect. Neurosci.* 10, 1092–1101. doi: 10.1093/scan/nsu167

Borod, J. C., Cicero, B. A., Obler, L. K., Welkowitz, J., Erhan, H. M., Santschi, C., et al. (1998). Right hemisphere emotional perception: evidence across multiple channels. *Neuropsychology* 12, 446–458. doi: 10.1037/0894-4105.12.3.446

Carretié, L. (2014). Exogenous (automatic) attention to emotional stimuli: a review. *Cogn. Affect. Behav. Neurosci.* 14, 1228–1258. doi: 10.3758/s13415-014-0270-2

Chang, Y., Xu, J., Shi, N., Zhang, B., and Zhao, L. (2010). Dysfunction of processing task-irrelevant emotional faces in major depressive disorder patients revealed by expression-related visual MMN. *Neurosci. Lett.* 472, 33–37. doi: 10.1016/j.neulet.2010.01.050

Chen, X., Pan, Z., Wang, P., Yang, X., Liu, P., You, X., et al. (2016). The integration of facial and vocal cues during emotional change perception: EEG markers. *Soc. Cogn. Affect. Neurosci.* 11, 1152–1161. doi: 10.1093/scan/nsv083

Ciesielski, B. G., Thomas, A., Zald, D. H., Olatunji, B. O., and García, A. V. (2010). Emotion modulation of visual attention: categorical and temporal characteristics. *PLoS One* 5:e13860. doi: 10.1371/journal.pone.0013860

Czigler, I. (2014). Visual mismatch negativity and categorization. *Brain Topogr.* 27, 590–598. doi: 10.1007/s10548-013-0316-8

Czigler, I., Balazs, L., and Pato, L. G. (2004). Visual change detection: event-related potentials are dependent on stimulus location in humans. *Neurosci. Lett.* 364, 149–153. doi: 10.1016/j.neulet.2004.04.048

Czigler, I., and Pató, L. (2009). Unnoticed regularity violation elicits change-related brain activity. *Biol. Psychol.* 80, 339–347. doi: 10.1016/j.biopsycho.2008.12.001

de Gelder, B. (2006). Towards the neurobiology of emotional body language. *Nat. Rev. Neurosci.* 7, 242–249. doi: 10.1038/nrn1872

de Gelder, B. (2009). Why bodies? Twelve reasons for including bodily expressions in affective neuroscience. *Philos. Trans. R. Soc. Lond.* 364, 3475–3484. doi: 10.1098/rstb.2009.0190

de Gelder, B., Snyder, J., Greve, D., Gerard, G., and Hadjikhani, N. (2004). Fear fosters flight: a mechanism for fear contagion when perceiving emotion expressed by a whole body. *Proc. Natl. Acad. Sci. USA* 101, 16701–16706. doi: 10.1073/pnas.0407042101

de Gelder, B., and van den Stock, J. (2011). The bodily expressive action stimulus test (BEAST). Construction and validation of a stimulus basis for measuring perception of whole body expression of emotions. *Front. Psychol.* 2:181. doi: 10.3389/fpsyg.2011.00181

de Gelder, B., Van den Stock, J., Meeren, H. K., Sinke, C. B., Kret, M. E., and Tamietto, M. (2010). Standing up for the body. Recent progress in uncovering the networks involved in the perception of bodies and bodily expressions. *Neurosci. Biobehav. Rev.* 34, 513–527. doi: 10.1016/j.neubiorev.2009.10.008

Delorme, A., and Makeig, S. (2004). Eeglab: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *J. Neurosci. Methods* 134, 9–21. doi: 10.1016/j.jneumeth.2003.10.009

Downing, P. E., and Peelen, M. V. (2011). The role of occipitotemporal body-selective regions in person perception. *Cogn. Neurosci.* 2, 186–203. doi: 10.1080/17588928.2011.582945

Downing, P. E., and Peelen, M. V. (2016). Body selectivity in occipitotemporal cortex: causal evidence. *Neuropsychologia* 83, 138–148. doi: 10.1016/j.neuropsychologia.2015.05.033

Faul, F., Erdfelder, E., Buchner, A., and Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behav. Res. Methods* 41, 1149–1160. doi: 10.3758/BRM.41.4.1149

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

Fujimura, T., and Okanoya, K. (2013). Correction: event-related potentials elicited by pre-attentive emotional changes in temporal context. *PLoS One* 8:e63703. doi: 10.1371/annotation/d92eb257-5d10-4e61-8210-44c5cdf5d896

Gayle, L. C., Gal, D. E., and Kieffaber, P. D. (2012). Measuring affective reactivity in individuals with autism spectrum personality traits using the visual mismatch negativity event-related brain potential. *Front. Hum. Neurosci.* 6:334. doi: 10.3389/fnhum.2012.00334

Giese, M. A., and Poggio, T. (2003). Neural mechanisms for the recognition of biological movements. *Nat. Rev. Neurosci.* 4, 179–192. doi: 10.1038/nrn1057

Gliga, T., and Dehaene-Lambertz, G. (2005). Structural encoding of body and face in human infants and adults. *J. Cogn. Neurosci.* 17, 1328–1340. doi: 10.1162/0898929055002481

Grèzes, J., Pichon, S., and de Gelder, B. (2007). Perceiving fear in dynamic body expressions. *NeuroImage* 35, 959–967. doi: 10.1016/j.neuroimage.2006.11.030

Gu, Y., Mai, X., and Luo, Y. (2013). Do bodily expressions compete with facial expressions? Time course of integration of emotional signals from the face and the body. *PLoS One* 8:e66762. doi: 10.1371/journal.pone.0066762

Gupta, R., and Déak, G. O. (2015). Disarming smiles: irrelevant happy faces slow post-error responses. *Cogn. Process.* 16, 427–434. doi: 10.1007/s10339-015-0664-2

Gupta, R., Hur, Y., and Lavie, N. (2016). Distracted by pleasure: effects of positive versus negative valence on emotional capture under load. *Emotion* 16, 328–337. doi: 10.1037/emo0000112

Gupta, R., and Raymond, J. E. (2012). Emotional distraction unbalances visual processing. *Psychon. Bull. Rev.* 19, 184–189. doi: 10.3758/s13423-011-0210-x

Gupta, R., and Srinivasan, N. (2015). Only irrelevant sad but not happy faces are inhibited under high perceptual load. *Cognit. Emot.* 29, 747–754. doi: 10.1080/02699931.2014.933735

Guthrie, D., and Buchwald, J. S. (1991). Significance testing of difference potentials. *Psychophysiology* 28, 240–244. doi: 10.1111/j.1469-8986.1991.tb00417.x

Hadjikhani, N., and de Gelder, B. (2003). Seeing fearful body expressions activates the fusiform cortex and amygdala. *Curr. Biol.* 13, 2201–2205. doi: 10.1016/j.cub.2003.11.049

Hillyard, S. A., and Anllo-Vento, L. (1998). Event-related brain potentials in the study of visual selective attention. *Proc. Natl. Acad. Sci. USA* 95, 781–787. doi: 10.1073/pnas.95.3.781

Hinojosa, J. A., Mercado, F., and Carretié, L. (2015). N170 sensitivity to facial expression: a meta-analysis. *Neurosci. Biobehav. Rev.* 55, 498–509. doi: 10.1016/j.neubiorev.2015.06.002

Ikeda, K., Sugiura, A., and Hasegawa, T. (2013). Fearful faces grab attention in the absence of late affective cortical responses. *Psychophysiology* 50, 60–69. doi: 10.1111/j.1469-8986.2012.01478.x

Kimura, M., Kondo, H., Ohira, H., and Schröger, E. (2012). Unintentional temporal context-based prediction of emotional faces: an electrophysiological study. *Cereb. Cortex* 22, 1774–1785. doi: 10.1093/cercor/bhr244

Kimura, M., Schröger, E., and Czigler, I. (2011). Visual mismatch negativity and its importance in visual cognitive sciences. *Neuroreport* 22, 669–673. doi: 10.1097/WNR.0b013e32834973ba

Kovarski, K., Latinus, M., Charpentier, J., Cléry, H., Roux, S., Houy-Durand, E., et al. (2017). Facial expression related vMMN: disentangling emotional from neutral change detection. *Front. Hum. Neurosci.* 11:18. doi: 10.3389/fnhum.2017.00018

Kret, M. E., Pichon, S., Grèzes, J., and de Gelder, B. (2011). Similarities and differences in perceiving threat from dynamic faces and bodies. An fMRI study. *NeuroImage* 54, 1755–1762. doi: 10.1016/j.neuroimage.2010.08.012

Kret, M. E., Roelofs, K., Stekelenburg, J. J., and Gelder, B. D. (2013). Emotional signals from faces, bodies and scenes influence observers' face expressions, fixations and pupil-size. *Front. Hum. Neurosci.* 7:810. doi: 10.3389/fnhum.2013.00810

Li, X., Lu, Y., Sun, G., Gao, L., and Zhao, L. (2012). Visual mismatch negativity elicited by facial expressions: new evidence from the equiprobable paradigm. *Behav. Brain Funct.* 8:7. doi: 10.1186/1744-9081-8-7

Maekawa, T., Goto, Y., Kinukawa, N., Taniwaki, T., Kanba, S., and Tobimatsu, S. (2005). Functional characterization of mismatch negativity to a visual stimulus. *Clin. Neurophysiol.* 116, 2392–2402. doi: 10.1016/j.clinph.2005.07.006

Marois, R., and Ivanoff, J. (2005). Capacity limits of information processing in the brain. *Trends Cogn. Sci.* 9, 296–305. doi: 10.1016/j.tics.2005.04.010

Meeren, H. K. M., de Gelder, B., Ahlfors, S. P., Hämäläinen, M. S., and Hadjikhani, N. (2013). Different cortical dynamics in face and body perception: an MEG study. *PLoS One* 8:e71408. doi: 10.1371/journal.pone.0071408

Meeren, H. K., van Heijnsbergen, C. C., and de Gelder, B. (2005). Rapid perceptual integration of facial expression and emotional body language. *Proc. Natl. Acad. Sci. USA* 102, 16518–16523. doi: 10.1073/pnas.0507650102

Muller, D., Roeber, U., Winkler, I., Trujillo-Barreto, N., Czigler, I., and Schroger, E. (2012). Impact of lower- vs. upper-hemifield presentation on automatic colour-deviance detection: a visual mismatch negativity study. *Brain Res.* 1472, 89–98. doi: 10.1016/j.brainres.2012.07.016

Pazoalvarez, P., Amenedo, E., and Cadaveira, F. (2015). Automatic detection of motion direction changes in the human brain. *Eur. J. Neurosci.* 19, 1978–1986. doi: 10.1111/j.1460-9568.2004.03273.x

Righart, R., and de Gelder, B. (2007). Impaired face and body perception in developmental prosopagnosia. *Proc. Natl. Acad. Sci. USA* 104, 17234–17238. doi: 10.1073/pnas.0707753104

Righart, R., and de Gelder, B. (2008). Rapid influence of emotional scenes on encoding of facial expressions: an erp study. *Soc. Cogn. Affect. Neurosci.* 3, 270–278. doi: 10.1093/scan/nsn021

Srinivasan, N., and Gupta, G. (2010). Emotion-attention interactions in recognition memory for distractor faces. *Emotion* 10, 207–215. doi: 10.1037/a0018487

Srinivasan, N., and Gupta, R. (2011). Global-local processing affects recognition of distractor emotional faces. *Q. J. Exp. Psychol.* 64, 425–433. doi: 10.1080/17470218.2011.552981

Stefanics, G., Csukly, G., Komlósi, S., Czobor, P., and Czigler, I. (2012). Processing of unattended facial emotions: a visual mismatch negativity study. *NeuroImage* 59, 3042–3049. doi: 10.1016/j.neuroimage.2011.10.041

Stekelenburg, J. J., and de Gelder, B. (2004). The neural correlates of perceiving human bodies: an erp study on the body-inversion effect. *Neuroreport* 15, 777–780. doi: 10.1097/00001756-200404090-00007

Susac, A., Ilmoniemi, R. J., Pihko, E., Ranken, D., and Supek, S. (2010). Early cortical responses are sensitive to changes in face stimuli. *Brain Res.* 1346, 155–164. doi: 10.1016/j.brainres.2010.05.049

Thierry, G., Pegna, A. J., Dodds, C., Roberts, M., Basan, S., and Downing, P. (2006). An event related potential component sensitive to images of the human body. *NeuroImage* 3, 871–879. doi: 10.1016/j.neuroimage.2006.03.060

Van de Riet, W. A., Grezes, J., and de Gelder, B. (2009). Specific and common brain regions involved in the perception of faces and bodies and the representation of their emotional expressions. *Soc. Neurosci.* 4, 101–120. doi: 10.1080/17470910701865367

van den Stock, J., Vandenbulcke, M., Sinke, C. B. A., and de Gelder, B. (2012). Affective scenes influence fear perception of individual body expressions. *Hum. Brain Mapp.* 35, 492–502. doi: 10.1002/hbm.22195

van Heijnsbergen, C. C. R. J., Meeren, H. K. M., Grèzes, J., and de Gelder, B. (2007). Rapid detection of fear in body expressions, an ERP study. *Brain Res.* 1186, 233–241. doi: 10.1016/j.brainres.2007.09.093

Vogel, B. O., Shen, C., and Neuhaus, A. H. (2015). Emotional context facilitates cortical prediction error responses. *Hum. Brain Mapp.* 36, 3641–3652. doi: 10.1002/hbm.22868

Yin, G. M., She, S. L., Zhao, L., and Zheng, Y. J. (2018). The dysfunction of processing emotional faces in schizophrenia revealed by expression-related visual mismatch negativity. *Neuroreport* 29, 814–818. doi: 10.1097/WNR.0000000000001037

Zhao, L., and Li, J. (2006). Visual mismatch negativity elicited by facial expressions under non-attentional condition. *Neurosci. Lett.* 410, 126–131. doi: 10.1016/j.neulet.2006.09.081

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Gender and the Body Size Aftereffect: Implications for Neural Processing

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Prolonged exposure to wide (thin) bodies causes a perceptual aftereffect such that subsequently viewed bodies appear thinner (wider) than they actually are. This phenomenon is known as visual adaptation. We used the adaptation paradigm to examine the gender selectivity of the neural mechanisms encoding body size and shape. Observers adjusted female and male test bodies to appear normal-sized both before and after adaptation to bodies digitally altered to appear heavier or lighter. In Experiment 1, observers adapted simultaneously to bodies of each gender distorted in opposite directions, e.g., thin females and wide males. The direction of resultant aftereffects was contingent on the gender of the test stimulus, such that in this example female test bodies appeared wider while male test bodies appeared thinner. This indicates at least some separation of the neural mechanisms processing body size and shape for the two genders. In Experiment 2, adaptation involved either wide females, thin females, wide males or thin males. Aftereffects were present in all conditions, but were stronger when test and adaptation genders were congruent, suggesting some overlap in the tuning of gender-selective neural mechanisms. Given that visual adaptation has been implicated in real-world examples of body size and shape misperception (e.g., in anorexia nervosa or obesity), these results may have implications for the development of body image therapies based on the adaptation model.

Keywords: adaptation, aftereffects, body image, body size and shape misperception, gender, neural representation

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INTRODUCTION

While human perception is impressive in many respects, it is by no means infallible. For example, many humans make consistent errors when estimating the size and shape of their own bodies – a phenomenon known as body size and shape misperception (BSSM; Challinor et al., 2017; Brooks et al., 2019b). It has been shown that some individuals who are obese or overweight may misperceive their body size as being normal (Truesdale and Stevens, 2008; Wetmore and Mokdad, 2012), while some individuals who are underweight, including those with the eating disorder *anorexia nervosa*, are prone to overestimate their body size (Probst et al., 1998; Cornelissen et al., 2017; Molbert et al., 2017). This example of regression to the mean for perceived body size has been referred to as "contraction bias" (Cornelissen et al., 2016).

In recent years, perceptual psychologists have sought a causal explanation for BSSM, suggesting that these phenomena may be real-world examples of perceptual aftereffects (Helmholtz, 1924; Challinor et al., 2017; Brooks et al., 2019b). It is well known that prolonged exposure to a particular sensory stimulus (the "adaptor") causes the perception of subsequently encountered "test" stimuli to be systematically biased. Often this aftereffect involves the test stimulus taking on perceived qualities that are, in a sense, opposite to the adaptor. For example, exposure to a yellow stimulus can lead to a neutral stimulus appearing blue (Helmholtz, 1924; Hurvich and Jameson, 1957). This process is known as visual adaptation. Alongside color, aftereffects have been demonstrated for other low-level stimulus properties such as motion, orientation and spatial frequency, as well as higher-level properties, such as the identity, race or gender of faces (Clifford and Rhodes, 2005). According to the visual adaptation model of BSSM, extended and repeated exposure to large bodies – those of friends or family members for example – may yield an aftereffect of underestimation, such that an individual's own body viewed in the mirror may appear smaller than it is. Conversely, repeated viewing of thin bodies, such as those of models in the media may cause a fattening aftereffect, leading individuals to overestimate their size (Brooks et al., 2019b; Challinor et al., 2017).

The effects of adaptation have been characterized as a perceptual recalibration, effected by a change in the response properties of cells activated by the adaptation stimulus (Barlow and Hill, 1963; Mollon, 1974; Ibbotson, 2005; Krekelberg et al., 2006). The adjustment of the relationship between objective stimulus qualities and the frequency of neural impulses means that the same sensory input will result in a different pattern of neural responses before and after adaptation, leading to a change of stimulus appearance. This allows investigators an opportunity to probe the neural mechanisms responsible for the processing and representation of sensory stimuli by assessing the magnitude of aftereffects under different experimental conditions, in particular when the properties of adaptors and test stimuli are manipulated.

Take, for example, the paradigm of contingent adaptation. Here, stimuli from two different categories are used for adaptation, each with opposite values on a separate stimulus dimension. For example, this paradigm has been used to investigate the neural substrates underlying the perception of facial structure for different race faces (Jaquet et al., 2008; Gwinn and Brooks, 2013, 2015b). If the two categories (here, faces from different racial groups) are processed by the same neural mechanism (see **Figure 1A**), then this mechanism should be affected by both the high value of one stimulus category (Caucasian adaptors whose features had been expanded toward the edges of the face) and the low value of the other stimulus category (East Asian adaptors with contracted features), leading to a cancelation of effects and a consequent absence of any measurable aftereffect (**Figure 1B**). Alternatively, if stimuli from the two categories are processed by separate mechanisms (**Figure 1C**), then independent contrasting aftereffects should be demonstrated for both stimulus types (**Figure 1D**). The result was simultaneous aftereffects of contraction for Caucasian test faces and expansion for East Asian test faces, suggesting that faces belonging to these categories are processed separately. Similar results have been shown for faces of different genders (Little et al., 2005; Jaquet et al., 2008; Gwinn and Brooks, 2015a) and even species (Little et al., 2008; Gwinn and Brooks, 2015a).

An alternative approach involves the technique of cross-adaptation. Unlike contingent adaptation, in this case an observer is exposed to only one type of adaptation stimulus. Insights into the details of neural representations are gained by assessing changes in the magnitude of aftereffects as the experimenter manipulates the similarity between the adaptor and the test stimulus. When the adaptor and test are highly similar, they will be processed by the same neurons (**Figure 2A**), and the potential for cross-adaptation will be maximal, such that aftereffects are similar in magnitude regardless of which test stimulus is used (**Figure 2B**). When adaptors and test stimuli differ, the magnitude of the aftereffect should decline to the extent that the neural populations recruited by the test stimulus are separate from those responsible for processing the adaptor. If entirely separate neural populations process the two categories (**Figure 2C**), then there should be no cross-adaptation at all, i.e., no recorded aftereffect when adaptor and test differ (**Figure 2D**). If the neural populations overlap to some extent (**Figure 2E**), partial cross-adaptation (i.e., a smaller aftereffect magnitude) should result (**Figure 2F**). Jaquet and Rhodes (2008) reported face aftereffects when adaptors and test stimuli differed in terms of their gender, suggesting an overlap in terms of the neural units responsible for processing these two stimulus categories. However, these cross-adaptation effects were smaller than the "simple-adaptation" effects observed when adaptors and test stimuli belonged to the same gender category, suggesting that this overlap was only partial.

Here, we use these two complementary paradigms to probe the neural mechanisms responsible for the perception of the size and shape of male and female bodies. While experiment 1 employs the technique of contingent adaptation, experiment 2 uses cross-adaptation.

EXPERIMENT 1: CONTINGENT ADAPTATION

In this experiment, participants are adapted simultaneously to images of male and female bodies that have been manipulated in opposite directions to appear either heavier or lighter than normal. If the perception of body size is mediated by a single neural population regardless of gender, both male and female adaptation stimuli would be expected to affect this mechanism, with their equal-and-opposite aftereffects canceling each other. This pattern of results represents the null hypothesis. As a result, no aftereffect should be observed for stimuli of either gender. However, if there is a degree of functional separation between the neural populations processing body size for males and female bodies, then the opposing adaptors should each affect a separate set of neurons, allowing us to hypothesize aftereffects with a direction that is contingent on the gender of the test stimulus being used.

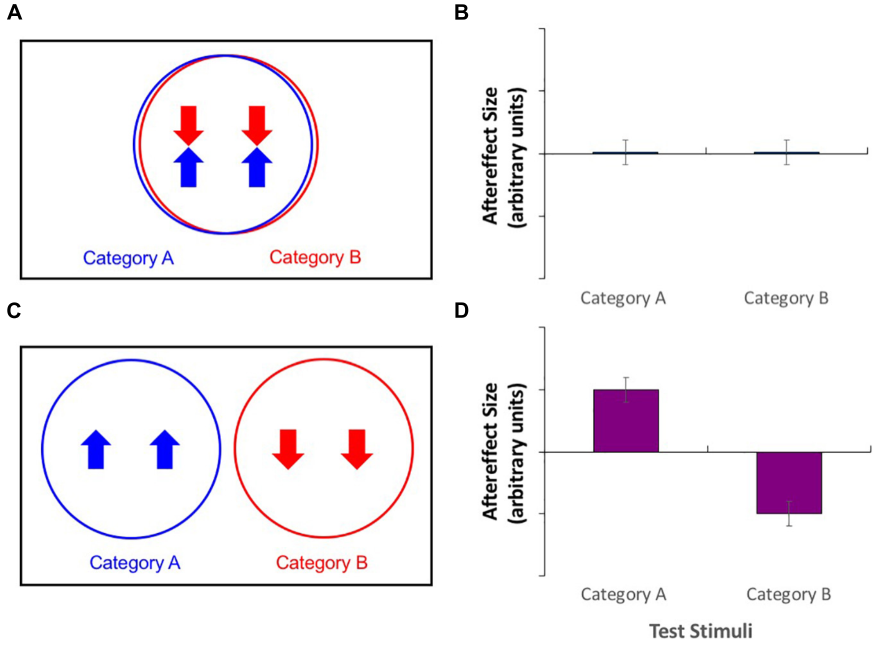

FIGURE 1 | (A,C) Venn diagrams of putative neural populations during adaptation to category A stimuli with a high value on a particular stimulus dimension, along with adaptation to category B stimuli with a low value. **(B,D)** Patterns of aftereffects for category A and category B test stimuli. **(A)** Adaptation effects cancel in category agnostic neural populations. **(B)** This produces no measurable aftereffects for either category of test stimulus. **(C)** Opposite direction adaptation effects in category selective neural populations. **(D)** This produces aftereffects whose directions are contingent on the category of the test stimuli.

Materials and Methods

Participants

Twenty-seven Caucasians aged between 18 and 40 participated in Experiment 1 (14 females, 13 males, $M_{age} = 21.22$, $SD = 0.51$). Of these, 15 were undergraduate psychology students and twelve were friends and family of one of the researchers. All participants were naïve as to the hypotheses, had normal or corrected-to-normal vision and gave written informed consent before participation. Both experiments were approved by the Macquarie University Human Research Ethics Committee (MQ HREC Ref 5201829753348, approved 03/05/2018).

Design

The experiment used a 2 × (2) mixed factorial design. The between-subjects factor – adaptation condition – had two levels: expanded male/contracted female (Male+/Female−) or contracted male/expanded female (Male−/Female+). The within subjects factor was the gender of the test stimuli with two levels: male and female. We measured the Point of Subjective Normality (PSN): the body size that the participant selected as appearing normal. PSN was measured before adaptation, as a baseline, and again after adaptation, to assess the effects of exposure. The dependent variable for all analyses was ΔPSN, calculated by subtracting pre-adaptation from post-adaptation scores. Positive ΔPSN values indicate that participants had selected larger bodies after adaptation. This suggests that an aftereffect of contraction had occurred, causing observers to compensate for the perceptual size reduction by declaring a larger stimulus to have a normal appearance. Conversely, negative ΔPSN values indicate that participants had selected smaller bodies after adaptation, suggesting that expansion aftereffects had occurred.

Stimuli

Body stimuli were created from photographs of males and females that were accessed from an archive of photos held by the Macquarie University Body Image and Ingestion Group. Images were standardized in terms of their viewpoint, pose, clothing, background, lighting and camera settings (see Brierley et al., 2016). In an attempt to minimize noise in the results due to variability in the stimuli selected, images of individuals with similar body compositions were chosen. The 18 body identities whose body fat percentage was closest to the mean of images of their gender in the archive were chosen for females ($M = 24.53$, $SD = 6.80$) and for males ($M = 15.88$, $SD = 6.98$). Within each set, all images were also within one standard deviation of the mean for BMI (females $M = 21.66$, $SD = 2.96$; males $M = 24.08$, $SD = 4.35$) and for muscle percentage (females $M = 71.64$, $SD = 6.45$; males $M = 79.30$, $SD = 6.62$). Two male and two female bodies were selected to serve as practice identities, and were not used in the data collection phases, leaving 16 experimental stimuli of each gender. Amongst these 16, eight were randomly selected to serve as test identities, while the other eight were used for adaptation.

To simulate variations of body size, Adobe Photoshop CC 2018 was used to create several versions of each of the selected body stimuli. Each photograph was subjected to an identical image manipulation to simulate larger and smaller body sizes using the horizontal "spherize" function. An elliptical region

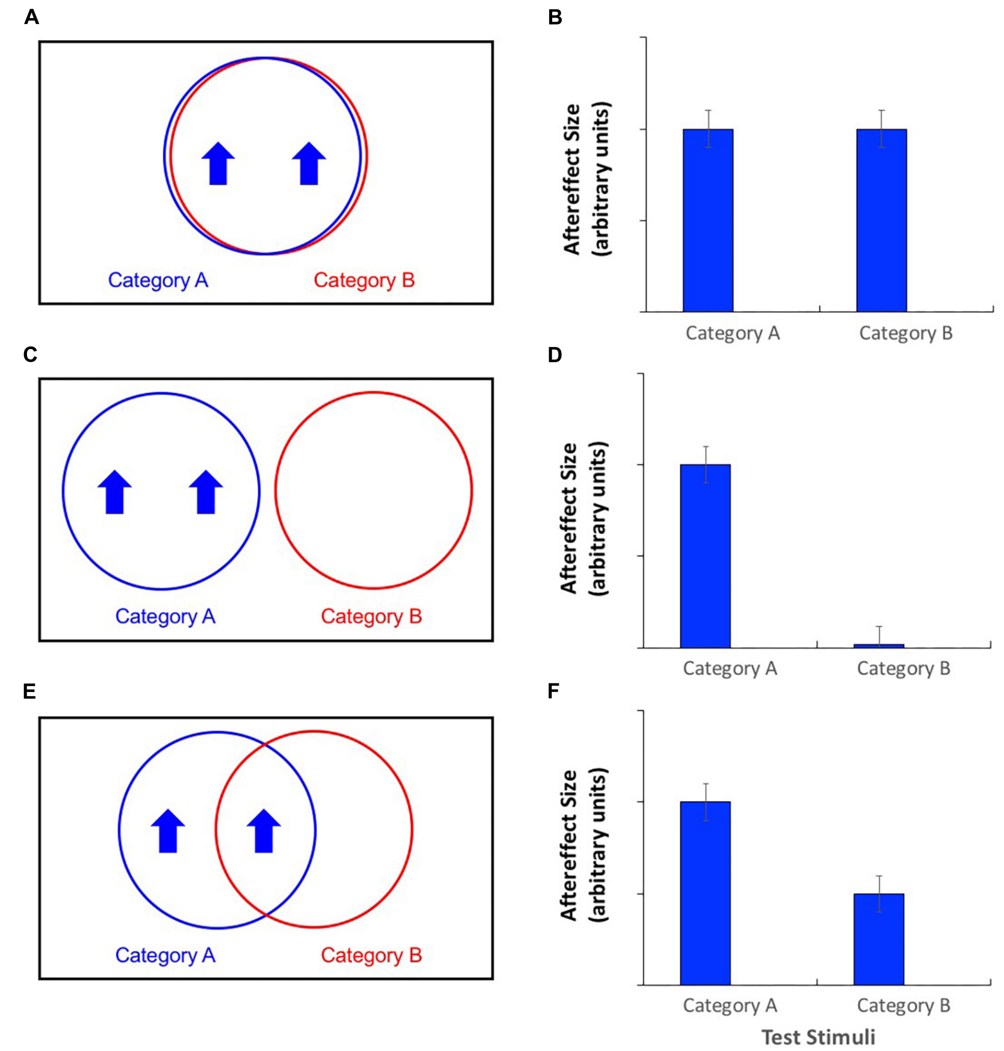

FIGURE 2 | (A,C,E) Venn diagrams of putative neural populations during adaptation to category A stimuli with a high value on a particular stimulus dimension. **(B,D,F)** Patterns of aftereffects for category A and category B test stimuli. **(A)** Category agnostic neural populations produce **(B)** complete cross-adaptation, i.e., aftereffects are equal in magnitude regardless of the test stimulus category. **(C)** Category selective neural populations produce **(D)** no cross-adaptation, i.e., aftereffects are non-existent for test stimuli from category B. **(E)** Partially category selective neural populations produce **(F)** partial cross-adaptation, i.e., aftereffects for category B test stimuli are significant, but smaller than for category A test stimuli.

of the image, stretching from neck to ankles, was selected. A feathered edge to this elliptical marquee ensured that the distortion smoothly integrated with the unmanipulated regions of the body (the face/head and feet). To create the two adaptation stimuli, each body stimulus was subjected to a −50% (contraction) and +50% (expansion) horizontal distortion (see **Figure 3**). For the test stimuli, 13 versions of the images were created in 5% increments from −30 to +30% expansion (see **Figure 4**). The heads of all stimuli were covered by a standardized black box to eliminate the possibility of face adaptation. All images were set to an aspect ratio of 2:3. Adaptation images were 1094 × 1641 pixels, while test images were presented at 820 × 1230 (3/4 of the size of the adaptation images) to reduce the effects of low-level adaptation (Brooks et al., 2018). Images were presented on a Dell P1130, 21″ color monitor using Matlab version 7, operating Psychophysics Toolbox extensions (Kleiner et al., 2007) and were viewed from a distance of 70 cm.

Procedure

In the practice phase, participants were familiarized with the procedure of selecting a normal body size using the body manipulation tool. This allowed participants to adjust the test body to ±30% of its original size by horizontally sliding the mouse from right (expanded image) to left (contracted image). The adjustment involved the display of the 13 test images appearing in sequence, giving the illusion of a smooth transition in body size. When the participant clicked the mouse, the size of the body on the screen was recorded as the PSN value.

In the baseline data collection phase, images of male and female bodies were presented and participants were required to adjust them to the size they perceived as "normal." On each trial, the initial size of the test body was chosen at random from the 13 possible sizes. There were eight test body identities for each gender and each identity was presented twice. Baseline PSN was calculated separately for male and female test conditions as the average body size selected across the 16 relevant trials.

FIGURE 3 | Example of a male identity used in the adaptation phase. The left body represents 50% contraction and the right body represents 50% expansion. The middle is the original image not used in adaptation.

Adaptation data were collected immediately following the baseline phase. Participants observed a 256 s "initial" adaptation sequence, where they were exposed to alternating images of the eight male and eight female adaptation bodies (e.g., Male + /Female−), each visible for a 2 s duration, repeated eight times. Subsequently, they were required to readjust the eight male and eight female test bodies to a "normal" size. In between each trial there was 12 s of "top up" exposure to maintain levels of visual adaptation before the next test body was presented. Here, a randomly chosen three male and three female adaptors were used. With genders alternating, each was again visible for 2 s. All other details were identical to the baseline phase.

Results

The change in the point of subjective normality between baseline and adaptation scores is plotted in **Figure 5** for both adaptation conditions, and for male (ΔPSN_{male}) and female (ΔPSN_{female}) test stimuli. From inspection, it is apparent that adaptation to expanded male bodies and contracted female bodies caused male test bodies to be perceived as smaller and female test bodies as larger (compared to baseline levels). In each case, participants made compensatory adjustments to the test stimuli using the body manipulation tool to reach a positive ΔPSN_{male} and a negative ΔPSN_{female}. In contrast,

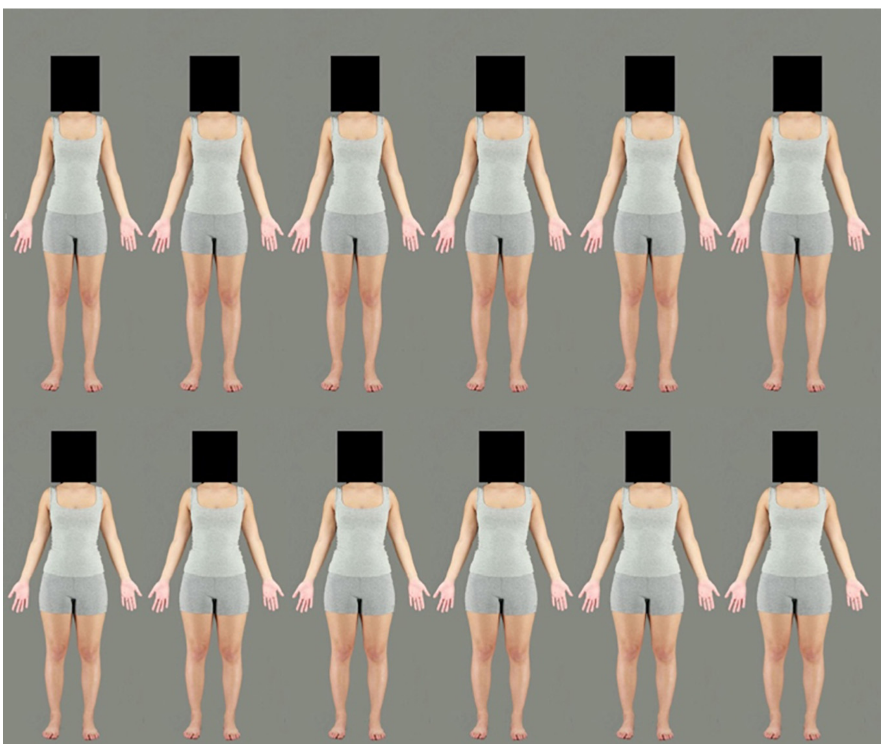

FIGURE 4 | Example of a female identity used in the test phase. Images ranging from the most contracted (–30%) on the top left to the most expanded (+30%) on the bottom right. The original body is not included in this figure.

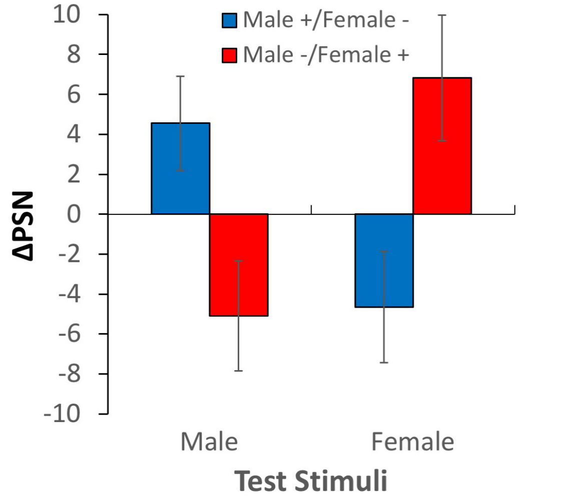

FIGURE 5 | Results of experiment 1. Changes in points of subjective normality for both adaptation conditions and test stimulus genders. Error bars show ± 1 SEM.

adaptation to contracted male bodies and expanded female bodies caused male test bodies to be perceived as larger and female test bodies to be perceived as smaller than they were before adaptation. These observations were confirmed by a 2-way ANOVA[1], where a significant interaction between adaptation direction and test gender reaffirmed the presence of contingent aftereffects $F_{(1,25)} = 12.045$, $p = 0.002$, $\eta_p^2 = 0.325$. As expected, there was no significant main effect of test gender $F_{(1,25)} = 0.201$, $p > 0.05$ or adaptation condition $F_{(1,25)} = 0.137$, $p > 0.05$.

Discussion

These results are inconsistent with a system with a single, gender-agnostic mechanism for processing the size and shape of body stimuli. Such a system would be exposed simultaneously to expanded and contracted stimuli, resulting in no net adaptation and no measurable aftereffect (see **Figures 1A,B**). Even if there had been a slight imbalance in the sizes and shapes of male and female stimuli, resulting in an asymmetric adaptation effect in the Male+/Female− compared to the Male−/Female+ adaptation condition, this should have resulted in equivalent PSNs when male and female bodies were used as test stimuli. This was clearly not the case. Instead, there is evidence of opposite aftereffects contingent on the gender of the test stimuli. This is consistent with the existence of gender-selective mechanisms that are engaged when the visual system processes body size and shape.

While it is clear that the systems processing body size and shape for male and female bodies are independent to some degree, the extent of their independence cannot be revealed by this experiment. It is possible that only some of the neurons are gender-selective, resulting in the observed contingent aftereffects. Meanwhile, other cells processing size and shape may be excited by body stimuli regardless of their gender, and in these neurons the opposite adaptation effects would cancel. As the degree of cancelation occurring in experiment 1 cannot be known, a different approach is required to determine whether the perception of body size and shape is mediated by fully or partially gender-selective mechanisms.

[1] Conducted using SPSS v.25.

EXPERIMENT 2: SIMPLE/CROSS ADAPTATION

In this experiment, observers are adapted to a single set of bodies of a given gender (male or female) that have either been expanded to simulate higher, or contracted to simulate lower body mass. *A priori*, it was considered unlikely that this could result in complete cross-adaptation (i.e., equivalent aftereffects for male and female test stimuli), as the gender-agnostic system that would produce such results has already been ruled out by experiment 1 (**Figures 2A,B**). This lack of a difference between the magnitudes of aftereffects represents the null hypothesis. However, two other possibilities remain, producing competing hypotheses. If judgments of body size and shape involves independent neural populations that are strictly gender selective (**Figure 2C**), then aftereffects established with one adaptation stimulus should be seen only when testing with stimuli of the same gender, with no transfer of this aftereffect to other-gender test stimuli (**Figure 2D**). However, if the systems underlying body size and shape perception for male and female stimuli are partially gender-selective (**Figure 2E**), we should observe a degree of transfer. This means that aftereffects should be significant when adaptation and test stimuli differ in terms of gender, yet these effects should be smaller in magnitude than when they have the same gender (**Figure 2F**).

Materials and Methods

This investigation was identical to Experiment 1, except in the following respects. Experiment 2 employed a 2 × 2 × (2) mixed factorial design. The sole within-subjects factor was the gender of the test bodies, with two levels: male and female. The first between-subjects factor – adaptation gender – had two levels: male or female, and second between-subjects factor – adaptation direction – also had two levels: expanded or contracted. Eighty-four Caucasian participants aged between 18 and 40 years old participated in ($M_{age} = 20.76$, $SD = 3.30$). Of these, 67 were undergraduate psychology students and seventeen were friends and family of the researcher. The results of four participants were removed for lack of compliance with instructions, leaving a total of eighty participants: 20 in each condition. Participants observed a 128 s adaptation sequence where they were randomly exposed to stimuli from one of the four adaptation conditions (eight identities, 2 s duration for each, eight repetitions). Between each trial there was a 6 s "top up" consisting of three of the adaptation identities, selected at random, to ensure maintenance of adaptation levels. These durations (initial and top up) match the exposure times for adaptors of each gender used in experiment 1 (i.e., half of the experiment 1 total adaptation duration).

Results

The results of Experiment 2, in terms of the adaptation-induced change in the point of subjective normality are plotted in **Figure 6**, for both male (ΔPSN_{male}) and female test stimuli (ΔPSN_{female}). From informal inspection, it appears that exposure to expanded adaptors causes PSNs to increase (**Figure 6A**), while exposure to contracted adaptors causes them to decrease (**Figure 6B**), as expected. As in experiment 1, this is consistent with a contraction aftereffect after adaptation to expanded figures, and an expansion aftereffect following adaptation to contracted figures. When the gender of adaptation and test stimuli match (simple adaptation conditions), these aftereffects are relatively large, on average exceeding a distortion level of 10% (or one fifth of the level of the adapting stimulus). Most importantly, when the gender of adaptation and test stimuli are different (cross-adaptation conditions), aftereffects are present for each adaptation condition, but in each case they are smaller than when adaptor and test have the same gender (simple adaptation).

Formal statistical tests confirmed these preliminary observations. One sample *t*-tests[2] showed statistically significant adaptation effects for all simple adaptation conditions (smallest effect: $t_{19} = -6.87$, $p = 0.0004$, $d = 1.54$), and all cross-adaptation conditions (smallest effect: $t_{19} = 3.57$, $p = 0.0018$, $d = 0.80$).[3] A 2 × 2 × (2) ANOVA[1] showed a significant main effect of adaptation direction $F_{(1,76)} = 202.967$, $p < 0.0005$, $\eta_p^2 = 0.728$, confirming the expected difference between the aftereffects in contracted and expanded conditions. In addition, a significant three-way interaction between adaptation direction, adaptation gender and test gender was revealed $F_{(1,76)} = 17.758$, $p < 0.0005$, $\eta_p^2 = 0.189$, confirming the predicted difference between simple adaptation and cross-adaptation ΔPSNs.[4]

To further examine the three-way interaction, paired *t*-tests[1] examined differences between ΔPSN_{male} and ΔPSN_{female} for each adaptation condition. In two cases, simple adaptation effects were significantly larger than cross-adaptation effects. For expanded male adaptors, ΔPSN_{male} values were significantly larger than ΔPSN_{female} values $t_{19} = 5.201$, $p < 0.0005$, $d = 1.163$. Similarly, for contracted female adaptors, ΔPSN_{female} values were significantly larger than ΔPSN_{male} values $t_{19} = 2.577$, $p = 0.018$, $d = 0.576$. However, in the other two conditions, although simple adaptation ΔPSN values were larger than those for cross-adaptation, these differences were not significant ($p > 0.05$).

An additional analysis was conducted to explicitly examine the overall difference between simple and cross-adaptation ΔPSNs across all adaptation conditions. Here, for each participant, ΔPSN_{male} and ΔPSN_{female} values were recoded as ΔPSN_{simple} and ΔPSN_{cross} (depending on the adaptation gender), and values from contracted adaptation conditions were "rectified" by multiplying by −1 to allow combination with data from expanded adaptation conditions (see **Figure 7**). Clear aftereffects were observed for both simple adaptation (one-sample *t*-test: $t_{79} = 13.893$, $p = 6.52 \times 10^{23}$, $d = 1.553$) and cross-adaptation conditions (one-sample *t*-test: $t_{79} = 9.745$, $p = 1.35 \times 10^{24}$, $d = 1.089$), with significantly larger effects for simple adaptation ($t_{79} = 3.999$, $p = 0.00014$, $d = 0.447$). The cross-adaptation effect was 71% the size of the simple adaptation effect.

[2]Performed using Microsoft Excel 2016.

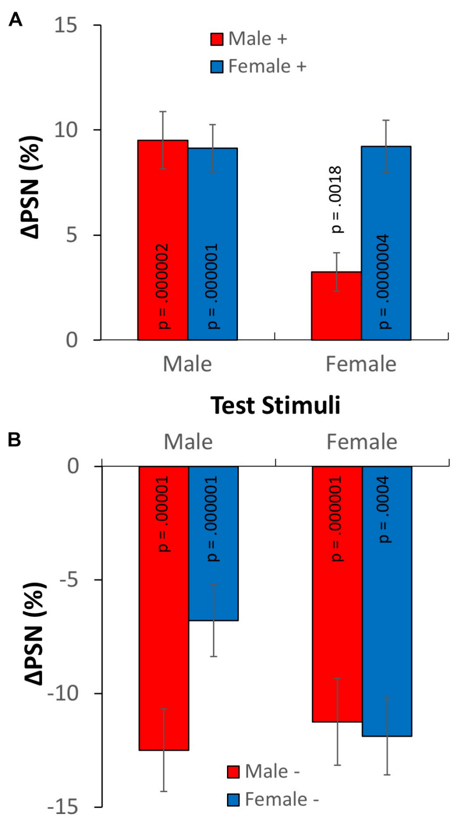

FIGURE 6 | Results of experiment 2. Changes in points of subjective normality for both adaptation conditions and test stimulus genders. **(A)** Adaptation to expanded stimuli. **(B)** Adaptation to contracted stimuli. Error bars show ± 1 SEM.

Discussion

Despite the overall demonstration of partial cross-adaptation when conditions are combined, the results of individual conditions are somewhat asymmetrical. While partial adaptation was clear and significant when adaptors were expanded males or contracted females, this effect was not significant when adaptors were expanded females or contracted males. A possible explanation may lie in the gender typicality of certain body shapes. It may be that, in general, stimuli that are expanded to a broader body shape size are viewed as more masculine, while those contracted to a more slender figure may be perceived as more feminine. Hence, broad female adaptors may

[3]These would be considered significant effects even with a conservative Bonferroni-corrected family wise critical *p*-value of 0.00625 (eight pairwise comparisons).

[4]In addition, there were significant main effects of adaptation gender $F_{(1,76)} = 4.287$, $p = 0.042$, $\eta p^2 = 0.053$ and test gender $F_{(1,76)} = 11.10$, $p = 0.001$, $\eta p^2 = 0.127$. These main effects held no theoretical interest and hence were not investigated further.

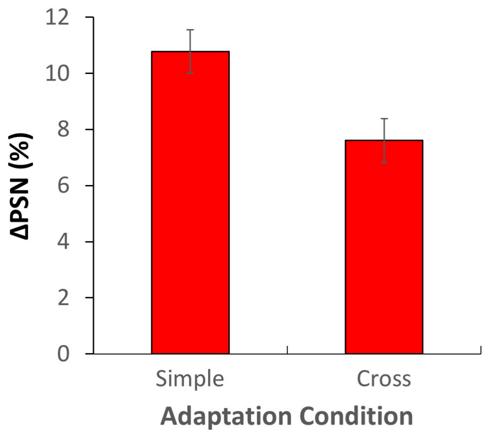

FIGURE 7 | Results of experiment 2, aggregated and recoded in terms of simple and cross-adaptation conditions. Error bars show ± 1 SEM.

cause some residual activation (and hence adaptation) of male-selective neurons, leading to a greater than expected degree of cross adaptation, and an inability to demonstrate a significant difference between simple and cross adaptation conditions. Conversely, thin male bodies may cause some unintended adaptation of female-selective neurons, reducing the chances of finding significant differences in this case. While this explanation is promising, it should be remembered that in Experiment 1, the condition combining these adaptors (Male−/Female+) was successful in demonstrating a contingent aftereffect (see **Figure 5**). It is possible that the direct contrast between the two sequentially presented adaptors accentuated their gender typicality in experiment 1 enough to allow the measurement of different effects for male and female test stimuli. Alternatively, the lack of significance in experiment 2 may simply be the result of noise.

The general demonstration of partial cross-adaptation suggests that the neural populations underlying the processing of size and shape are partially gender-selective (as in **Figures 2E,F**). Some neurons are activated by stimuli of either gender, and it is these units that are responsible for the transfer of aftereffects between adaptation stimuli from one category and test stimuli from another. However, transfer of the aftereffect is not complete, suggesting that some neurons process stimuli for one gender only, such that their adaptation does not result in an aftereffect when opposite gender test stimuli are used.

GENERAL DISCUSSION

This study is the first to investigate gender-selectivity in the neural populations processing body size and shape. Inferences concerning the properties of these groups of cells are made possible through the psychophysical method of visual adaptation, and the examination of aftereffects while manipulating the congruence between the gender of adaptors and test stimuli. The two experiments provide consistent and complementary findings. First, experiment 1's contingent aftereffects established a degree of gender independence in the processing of body stimuli. Experiment 2's observation of partial cross-adaptation confirmed this finding while establishing that the independence is far from complete. Taken together, these findings suggest that a proportion of the underlying neural populations behave in a gender agnostic manner to some extent. Although it is not possible to precisely quantify the level, experiment 2's observation of approximately 70% cross-adaptation suggests a small-to-medium degree of gender-selectivity. In broad agreement with this, it is notable that in experiment 1, contingent aftereffects were approximately half the size of simple adaptation effects shown in experiment 2, which used the same adaptation stimuli and exposure durations. This is consistent with the idea that in experiment 1, gender-agnostic cells were adapted to bodies of each gender manipulated in opposite directions, and that this led to a degree of cancelation of the adaptation and hence a smaller measured aftereffect.

Although efforts were made to ensure that all details of our body stimuli were standardized, we acknowledge that gender of the subject is not the only difference between the male and female stimulus sets. An reviewer noticed that the neckline of the singlets and the shade of the shorts differ subtly in our male and female stimuli, and hence there exists the technical possibility that if participants encoded these differences, this may constitute a basis for the phenomena of contingent adaptation and partial cross adaptation seen in our study. However, we consider this unlikely. From observation, we find that gender, communicated through body shape, is the most salient difference between the two stimulus sets, and hence the most likely basis for the categorical distinction. While it seems plausible that, either through evolution or through plasticity and perceptual learning, the brain may have developed neural mechanisms that are selective for the natural categories of stimulus gender, it would seem surprising if it contained similar mechanisms selective for the neck-line or shade of shorts used in our study.

The paradigms of contingent and cross-adaptation have been used previously to investigate the properties of neurons processing body size and shape. For example, a recent study showed substantial cross-adaptation between body stimuli that were oriented either at the same angle, or at right angles to the adapting stimulus (Brooks et al., 2018). Substantial cross-adaptation suggested that the judgment of body size and shape is a high-level process, relying on an object-centered frame of reference, rather than a low-level retinotopic one. In addition, Brooks et al. (2016) conducted an investigation similar to the current study, using body stimuli depicting the observer ("self"), and depicting another individual ("other") matched in terms of gender, race, age and BMI. Contingent adaptation was evident, suggesting a degree of independence in the processing of these two stimulus categories. As in the current study, cross-adaptation was also demonstrated, suggesting that the selectivity for self/other was only partial. In contrast, Gould-Fensom et al. (2019) were unable to show any contingent body size and shape adaptation using bodies from different racial groups (East Asian and Caucasian). A demonstration of 100% cross-adaptation between bodies from the two groups in a second experiment confirmed that the neurons are race-agnostic, suggesting that the lack of contingent aftereffects is likely to be due to substantial transfer and cancelation of aftereffects that are opposite in direction.

The current study presents strong evidence for the existence of partially gender selective mechanisms for the perception of body size and shape, yet there are several matters of interest on which it is unable to shed light. One such issue is the location of the neural structures responsible for our results. Various body-sensitive brain areas have been identified, some of which show modulation of activity when observers view bodies of different sizes. These areas, including the fusiform body area (FBA) and the extrastriate body area (EBA) (Hodzic et al., 2009; Aleong and Paus, 2010; Hummel et al., 2013; Gandolfo and Downing, 2019); the lateral occipital cortex (LOC), and the middle frontal gyrus (MFG) (Mohr et al., 2011) may be considered candidates for the neural locus of body size and shape judgments. More recent fMRI work has revealed at that both gender and weight can be decoded from distributed body-selective areas (including EBA and FBA) even when the classifier is trained and tested with body stimuli of different heights (Foster et al., 2019). However, this study is unable to reveal whether sex-selective cells in these regions also process body size (i.e., weight), as suggested by our contingent and cross-adaptation results, or whether these two stimulus attributes are processed by separate cells in the same general brain vicinity (for example, within an fMRI voxel). Body size and shape judgments may depend on responses in various neural populations in different anatomical locations or at different levels of the processing chain, and each of these may show different degrees of gender selectivity. For example, it is possible that at one level, cells are strictly gender specific (responding only to the gender for which they are selective, as in **Figure 2C**), but at another level, cells are completely gender-agnostic (responding equally to all bodies regardless of their gender, as in **Figure 2A**). While the contingent aftereffects of experiment 1 would be explained by responses in the former pool of neurons, the cross-adaptation demonstrated in experiment 2 would be explained by activity in the latter.

Although the Venn diagrams in **Figures 1**, **2** offer an intuitive depiction of size and shape perception mechanisms with varying degrees of gender selectivity, it should be acknowledged that they are somewhat simplistic. For example, these diagrams show a maximum of three types of cell: those that are strictly male-selective, those that are strictly female-selective, and those that are gender agnostic, being equally well stimulated by male or female body stimuli. Given that neither gender nor sex are strictly dichotomous variables, and that observers perceive bodies as varying in gender typicality (Palumbo et al., 2013), this is likely to be an oversimplification, and it may be more appropriate to consider the responses of cells to body stimuli along a continuum of gender typicality. Although the gender tuning of body selective cells has not been measured, based on the encoding of gender for faces (Gwinn and Brooks, 2015a), it seems likely that cells may show broad tuning to the gender of stimulus bodies, with vigorous responding to figures that are typical of the gender to which the cells are tuned, and a gradual reduction of activity as the gender typicality of the stimulus is reduced.

While neuroscientists interpret the results of high-level adaptation experiments in terms of the recalibration of response properties amongst various neural populations (Barlow and Hill, 1963; Krekelberg et al., 2006), psychologists – particularly when discussing the effects of face adaptation – tend to couch these effects in terms of the malleability of perceptual “norms” (Clifford and Rhodes, 2005; Jaquet and Rhodes, 2008; Jaquet et al., 2008). Perceptual norms are averages of all stimuli of a particular category that an individual has encountered. For example, an observer’s face norm would have average features located in the mean position across all faces that the observer has seen. Every time a new face is encountered, it is encoded in terms of its deviation from the norm face along a number of image dimensions in “face space” (Valentine, 1991). The effect of adaptation is to shift the norm toward the adapting stimulus, such that subsequently seen stimuli tend to be perceived to be, in this space, opposite to the adaptor (Clifford and Rhodes, 2005). When contingent adaptation is demonstrated, for example between categories such as male and female faces, this is seen as evidence for distinct norms for each of the categories, each of which has been biased in opposite directions (Jaquet and Rhodes, 2008; Jaquet et al., 2008; Gwinn and Brooks, 2013, 2015a,b). In terms of bodies, a similar interpretation can be applied to our findings, using a “body space” framework (Rhodes et al., 2013; Sturman et al., 2017). While the demonstration of contingent adaptation can only be accounted for by separate norms, cross-adaptation suggests that a gender-agnostic norm also exists, possibly at another level of processing.

The current study is not the first to examine body adaptation in the context of gender. A recent study by Brooks et al. (2019a) showed that aftereffects of perceived muscle and fat levels are larger in magnitude when the stimuli (adaptation and test) match the gender of the observer.[5] Although the current study focuses on inferences regarding the neural processing of body stimuli, it may also carry implications for real-world body image issues such as BSSM, especially when combined with the aforementioned results. As mentioned in the introduction, it has recently been suggested that perceptual aftereffects may underlie these misperceptions (Brooks et al., 2019b; Challinor et al., 2017). If this is true, then the current results offer predictions regarding the manifestation of BSSM. If extensive exposure to certain body types in the media or in one’s local environment does cause aftereffects to be experienced when viewing one’s own body in the mirror, it would be expected that the gender of the bodies being viewed would have an influence. For example, whereas a male who extensively views female fashion models on TV or social media may experience a degree of BSSM (overestimation), a larger effect

[5]In addition, Palumbo et al. (2013) demonstrated that exposure to typical male or female bodies could cause a shift in the perceived masculinity/femininity of otherwise androgynous-looking bodies. As in Brooks et al. (2019b) effects were largest when adaptation stimuli matched the gender of the observer.

would be expected for females consuming the same media. Similarly, if an overweight family includes many more males than females, we may expect BSSM to develop in the form of underestimation. However, males would be expected to suffer to a greater degree in this case. While it cannot be asserted that visual adaptation is the underlying cause of BSSM, the use of adaptation and the observation of aftereffects serves as a potent tool to examine the neural and psychological underpinnings of body size and shape misperception. This is an essential first step in explaining, and, perhaps, informing therapeutic interventions for, conditions involving body size and shape misperception (BSSM).

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

Both experiments were reviewed and approved by Macquarie University Human Research Ethics Committee. All participants provided informed consent in writing.

AUTHOR CONTRIBUTIONS

KB was responsible for the conception and design, the analysis and interpretation of data, original drafting, and final approval of the submitted version. EB was responsible for aspects of the design, the analysis and interpretation of data, aspects of original drafting, and final approval of the submitted version. JM, RS, DM, and IS made substantial contributions to the interpretation of data, critical revisions for important intellectual content, and final approval of the submitted version.

REFERENCES

Aleong, R., and Paus, T. (2010). Neural correlates of human body perception. *J. Cogn. Neurosci.* 22, 482–495. doi: 10.1162/jocn.2009.21211

Barlow, H. B., and Hill, R. M. (1963). Selective sensitivity to direction of movement in ganglion cells of the rabbit retina. *Science* 139, 412–414.

Brierley, M. E., Brooks, K. R., Mond, J., Stevenson, R. J., and Stephen, I. D. (2016). The body and the beautiful: health, attractiveness and body composition in men's and women's bodies. *PLoS One* 11:e0156722. doi: 10.1371/journal.pone.0156722

Brooks, K. R., Clifford, C. W. G., Stevenson, R. J., Mond, J., and Stephen, I. D. (2018). The high-level basis of body adaptation. *R. Soc. Open Sci.* 5:172103. doi: 10.1098/rsos.172103

Brooks, K. R., Keen, E., Sturman, D., Mond, J., Stevenson, R. J., and Stephen, I. D. (2019a). Muscle and fat aftereffects and the role of gender: implications for body image disturbance. *PsyArXiv*

Brooks, K. R., Mond, J., Mitchison, D., Stevenson, R. J., Challinor, K. L., and Stephen, I. D. (2019b). Looking at the figures: visual adaptation as a mechanism for body size and shape misperception. *Perspect. Psychol. Sci.* doi: 10.1177/1745691619869331

Brooks, K. R., Mond, J. M., Stephen, I. D., and Stevenson, R. J. (2016). Body image distortion and exposure to extreme body types: contingent adaptation and cross adaptation for self and other. *Front. Neurosci.* 10:334. doi: 10.3389/fnins.2016.00334

Challinor, K. L., Mond, J., Stephen, I. D., Mitchison, D., Stevenson, R. J., Hay, P., et al. (2017). Body size and shape misperception and visual adaptation: an overview of an emerging research paradigm. *J. Int. Med. Res.* 45, 2001–2008. doi: 10.1177/0300060517726440

Clifford, C. W., and Rhodes, G. (2005). *Fitting the Mind to the World: Adaptation and After-Effects in High-Level Vision*, Vol. 2. Oxford: Oxford University Press.

Cornelissen, K. K., Gledhill, L. J., Cornelissen, P. L., and Tovée, M. J. (2016). Visual biases in judging body weight. *Br. J. Health Psychol.* 21, 555–569. doi: 10.1111/bjhp.12185

Cornelissen, K. K., McCarty, K., Cornelissen, P. L., and Tovée, M. J. (2017). Body size estimation in women with anorexia nervosa and healthy controls using 3D avatars. *Sci. Rep.* 7, 1–15. doi: 10.1038/s41598-017-15339-z

Foster, C., Zhao, M., Romero, J., Black, M. J., Mohler, B. J., Bartels, A., et al. (2019). Decoding subcategories of human bodies from both body- and face-responsive cortical regions. *Neuroimage* 202:116085. doi: 10.1016/j.neuroimage.2019.116085

Gandolfo, M., and Downing, P. E. (2019). Causal evidence for expression of perceptual expectations in category-selective extrastriate regions. *Curr. Biol.* 29, 2496.e3–2500.e3. doi: 10.1016/j.cub.2019.06.024

Gould-Fensom, L., Tan, C. B. Y., Brooks, K. R., Mond, J., Stevenson, R. J., and Stephen, I. D. (2019). The thin white line: adaptation suggests a common neural mechanism for judgements of Asian and Caucasian body size. *PsyArXiv*

Gwinn, O. S., and Brooks, K. R. (2013). Race-contingent face aftereffects: a result of perceived racial typicality, not categorization. *J. Vis.* 13:13. doi: 10.1167/13.11.13

Gwinn, O. S., and Brooks, K. R. (2015a). Face encoding is not categorical: consistent evidence across multiple types of contingent aftereffects. *Vis. Cogn.* 23, 867–893. doi: 10.1080/13506285.2015.1091800

Gwinn, O. S., and Brooks, K. R. (2015b). No role for lightness in the encoding of Black and White: race-contingent face aftereffects depend on facial morphology, not facial luminance. *Vis. Cogn.* 23, 597–611. doi: 10.1080/13506285.2015.1061085

Helmholtz, H. (1924). in *Handbook of Physiological Optics*, Vol. 2, ed. J. P. C. Southall, (Washington, DC: Optical Society of America). doi: 10.1080/13506285.2015.1061085

Hodzic, A., Kaas, A., Muckli, L., Stirn, A., and Singer, W. (2009). Distinct cortical networks for the detection and identification of human body. *Neuroimage* 45, 1264–1271. doi: 10.1016/j.neuroimage.2009.01.027

Hummel, D., Rudolf, A. K., Brandi, M.-L., Untch, K.-H., Grabhorn, R., Hampel, H., et al. (2013). Neural adaptation to thin and fat bodies in the fusiform body area and middle occipital gyrus: an fMRI adaptation study. *Hum. Brain Mapp.* 34, 3233–3246. doi: 10.1002/hbm.22135

Hurvich, L. M., and Jameson, D. (1957). An opponent-process theory of color vision. *Psychol. Rev.* 64:384. doi: 10.1037/h0041403

Ibbotson, M. R. (2005). "Physiological mechanisms of adaptation in the visual system," in *Fitting the Mind to the World: Adaptation and Aftereffects in High-Level Vision*, eds C. W. G. Clifford, and G. Rhodes, (Oxford: Oxford University Press), 17–45.

Jaquet, E., and Rhodes, G. (2008). Face aftereffects indicate dissociable, but not distinct, coding of male and female faces. *J. Exp. Psychol. Hum. Percept. Perform.* 34, 101–112. doi: 10.1037/0096-1523.34.1.101

Jaquet, E., Rhodes, G., and Hayward, W. G. (2008). Race-contingent aftereffects suggest distinct perceptual norms for different race faces. *Vis. Cogn.* 16, 734–753. doi: 10.1080/13506280701350647

Kleiner, M., Brainard, D., Pelli, D., Ingling, A., Murray, R., and Broussard, C. (2007). What's new in Psychtoolbox-3. *Perception* 36, 1–16.

Krekelberg, B., Boynton, G. M., and Van Wezel, R. J. (2006). Adaptation: from single cells to BOLD signals. *Trends Neurosci.* 29, 250–256. doi: 10.1016/j.tins.2006.02.008

Little, A. C., DeBruine, L. M., and Jones, B. C. (2005). Sex-contingent face aftereffects suggest distinct neural populations code male and female faces. *Proc. R. Soc. Lond. Ser. B* 272, 2283–2287. doi: 10.3389/fpsyg.2015.01829

Little, A. C., DeBruine, L. M., Jones, B. C., and Waitt, C. (2008). Category contingent aftereffects for faces of different races, ages and species. *Cognition* 106, 1537–1547. doi: 10.1016/j.cognition.2007.06.008

Mohr, H. M., Röder, C., Zimmermann, J., Hummel, D., Negele, A., and Grabhorn, R. (2011). Body image distortions in bulimia nervosa: investigating body size overestimation and body size satisfaction by fMRI. *Neuroimage* 56, 1822–1831. doi: 10.1016/j.neuroimage.2011.02.069

Molbert, S. C., Klein, L., Thaler, A., Mohler, B. J., Brozzo, C., Martus, P., et al. (2017). Depictive and metric body size estimation in anorexia nervosa and bulimia nervosa: a systematic review and meta-analysis. *Clin. Psychol. Rev.* 57, 21–31. doi: 10.1016/j.cpr.2017.08.005

Mollon, J. D. (1974). After-effects and the brain. *New Sci.* 61, 479–482.

Palumbo, R., Laeng, B., and Tommasi, L. (2013). Gender-specific aftereffects following adaptation to silhouettes of human bodies. *Vis. Cogn.* 21, 1–12. doi: 10.1080/13506285.2012.753970

Probst, M., Vandereycken, W., Van Coppenolle, H., and Pieters, G. (1998). Body size estimation in anorexia nervosa patients: the significance of overestimation. *J. Psychosom. Res.* 44, 451–456. doi: 10.1016/s0022-3999(97)00270-5

Rhodes, G., Jeffery, L., Boeing, A., and Calder, A. J. (2013). Visual coding of human bodies: perceptual aftereffects reveal norm-based, opponent coding of body identity. *J. Exp. Psychol. Hum. Percept. Perform.* 39, 313–317. doi: 10.1037/a0031568

Sturman, D., Stephen, I. D., Mond, J., Stevenson, R. J., and Brooks, K. R. (2017). Independent aftereffects of fat and muscle: implications for neural encoding, body space representation, and body image disturbance. *Sci. Rep.* 7:40392. doi: 10.1038/srep40392

Truesdale, K. P., and Stevens, J. (2008). Do the obese know they are obese? *N. C. Med. J.* 69, 188–194.

Valentine, T. (1991). A unified account of the effects of distinctiveness, inversion, and race in face recognition. *Q. J. Exp. Psychol.* 43, 161–204. doi: 10.1080/14640749108400966

Wetmore, C. M., and Mokdad, A. H. (2012). In denial: misperceptions of weight change among adults in the United States. *Prevent. Med.* 55, 93–100. doi: 10.1016/j.ypmed.2012.04.019

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An Assessment of Computer-Generated Stimuli for Use in Studies of Body Size Estimation and Bias

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Inaccurate body size judgments are associated with body image disturbances, a clinical feature of many eating disorders. Accordingly, body-related stimuli have become increasingly important in the study of estimation inaccuracies and body image disturbances. Technological advancements in the last decade have led to an increased use of computer-generated (CG) body stimuli in body image research. However, recent face perception research has suggested that CG face stimuli are not recognized as readily and may not fully tap facial processing mechanisms. The current study assessed the effectiveness of using CG stimuli in an established body size estimation task (the "bodyline" task). Specifically, we examined whether employing CG body stimuli alters body size judgments and associated estimation biases. One hundred and six 17- to 25-year-old females completed the CG bodyline task, which involved estimating the size of full-length CG body stimuli along a visual analogue scale. Our results show that perception of body size for CG stimuli was non-linear. Participants struggled to discriminate between extreme bodies sizes and overestimated the size change between near to average bodies. Furthermore, one of our measured size estimation biases was larger for CG stimuli. Our collective findings suggest using caution when employing CG stimuli in experimental research on body perception.

Keywords: computer-generated bodies, body size estimation, biases, regression to the mean, serial dependence, body image disturbance

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INTRODUCTION

Eating disorders are an increasingly prevalent health concern. It is estimated that 15% of Australian women have experienced an eating disorder during their lifetime, which has necessitated clinical intervention (The Butterfly Foundation, 2012). Eating disorders are generally considered as encompassing a pervasive disturbance of eating and/or eating-related behaviors that lead to a disordered consumption or absorption of food and substantial impairments in mental or physical health (American Psychiatric Association, 2013). One of the core diagnostic features in eating disorders, such as anorexia nervosa, is a disturbance in the way one's body is experienced (American Psychiatric Association, 2013). Additionally, body image disturbance is a clinical marker of many other subtypes of eating disorders too, such as bulimia nervosa and binge-eating disorder (Zanetti et al., 2013; Lewer et al., 2016), and it can be very difficult to treat, even following recovery (Eshkevari et al., 2014). It is not surprising then, that a substantial amount of research has been dedicated to understanding the mechanisms underlying body image disturbance (for a review of some of the identified mechanisms, see Cash and Deagle, 1997; Gaudio et al., 2014; Riva and Dakanalis, 2018). Regarding the perceptual component of body image disturbance, it has been found that individuals with anorexia nervosa and bulimia nervosa tend to overestimate their body size more than healthy controls (Vocks et al., 2007; Gardner and Brown, 2014). Several research groups have sought to identify potentially underlying perceptual biases and distortions, such as adaptation, regression to the mean, and serial dependence biases, which may be linked to these body image disturbances (see: Cornelissen et al., 2016; Mohr et al., 2016; Sturman et al., 2017; Alexi et al., 2018, 2019). Within this literature, there have been considerable variations in the types of body stimuli used to study judgments of body size and weight.

Early on, methodologies involved the use of schematic drawings of participants' estimated size (Slade, 1985), distorting mirror techniques (Traub and Orbach, 1964), and silhouette methods (Bell et al., 1986; Skrzypek et al., 2001). Researchers then began to use image and video distortion techniques that involved adjusting body image widths to produce a body size change (Slade, 1985; Taylor and Cooper, 1992; Skrzypek et al., 2001). However, it has now been established that horizontal stretching not only gives the body an unrealistic appearance, but can also preserve key size markers in the original image, such as hip-to-waist ratios, which may impact the validity of findings (Dondzilo et al., 2018).

More recently, the advancement and accessibility of photographic and computer graphic technology have led to an increased use of real and computer-generated (CG) body images, which vary along the continuum, in the study of body image distortion. Real body stimuli have been used in a broad range of body image-related studies (e.g., Blechert et al., 2010; Hummel et al., 2013; Alexi et al., 2018, 2019), and have the advantage of providing an ecologically representative view of the human body. Real body images are usually acquired by photographing participants or sourced from the Internet. However, sourcing real body images using these methodologies can be challenging, particularly if full-length body images varying in body size and weight are required and can result in unwanted heterogeneity due to factors such as clothing, posture, and attractiveness, to name a few (Moussally et al., 2017).

CG body image stimuli provide an appealing alternative to real body stimuli, as they address many of these challenges. CG body stimuli are easily created through powerful yet relatively inexpensive CG imagery software that allows for the systematic manipulation of body characteristics, such as weight and size, thus creating precise and reproducible stimulus changes (Moussally et al., 2017). While CG stimuli can be highly human-like in appearance, distinct differences to real photographs are often noted (Farid and Bravo, 2012; Fan et al., 2014). For instance, within the field of face perception and computer graphics, research has identified unrealistic texture, illumination, and shading as factors that can decrease realism in CG stimuli (Fan et al., 2012, 2014; Crookes et al., 2015).

One concern, then, is that the reduction of visual realism in CG stimuli may consequently hamper processing mechanisms. In particular, a face perception study conducted by Crookes et al. (2015) examined how well CG face images tap face expertise abilities by comparing facial recognition abilities for own- and other-race faces across real and CG face images. Their findings revealed that recognition and discrimination accuracy of own-race faces were significantly diminished for CG faces, compared to real faces. The authors concluded that CG face stimuli may not entirely capture and tap face expertise (Crookes et al., 2015). This is likely to be because textural information is important in face recognition (Crookes et al., 2015). These findings are in concordance with other face perception studies, which have found that CG face images disrupt other facial processing mechanisms, such as perception of trustworthiness (Balas and Pacella, 2017) and face memory (Balas and Pacella, 2015).

Conversely, within the body perception literature, there have only been two published comparisons between CG and real bodies that we are aware of. The first by Tovée et al. (2012) and the second by Cornelissen et al. (2016). They found comparable results between CG and real body stimuli. However, in the first instance, attractiveness and health ratings were compared (Tovée et al., 2012), which are different dimensions of judgment from body size judgments. In the second instance, Cornelissen et al. (2016) compared the use of CG and real body images in the examination of body size sensitivity. However, this comparison used different Body Mass Index (BMI) size ranges between the CG (eight BMI ranges) and real (four BMI ranges) body stimuli (Cornelissen et al., 2016). For example, the largest BMI used in the real body condition was 26.5, versus 43 in the CG condition. Because the stimuli were not matched across each of the BMI groupings, a direct comparison of the two stimulus types appears problematic. Furthermore, if there are variations in body size judgments between CG and real stimuli, these are likely to be more pronounced in statistical extremes, where weight characteristics (e.g., visible emaciation, cellulite etc.) may be less well represented in CG stimuli. Additionally, the question regarding the effect of CG bodies on body size biases, such as serial dependence, is unexplored. Therefore, the current research sought to examine the efficacy of Poser-produced (Smith Micro Software, 2015) CG body stimuli to study body size judgments and whether using CG stimuli alters the magnitude and nature of two known biases that occur in the judgment of body size: regression to the mean and serial dependence.

Regression to the mean is a commonly reported bias in body size judgments (Cornelissen et al., 2016) and this bias occurs when judgments of stimuli are perceived to be closer to the mean of a set than they really are. In a study by Cornelissen et al. (2015), healthy controls with high psychological symptoms, including depression and eating and weight concerns, were shown to differ in their overall magnitude of body size estimations (i.e., they consistently overestimated their body size), but their slope of judgments (a common measure of regression to the mean) was unchanged (Cornelissen et al., 2015).

In contrast, serial dependence is a recently discovered bias in body perception, in which perceptual size judgments of stimuli are biased toward the size of previously viewed stimuli. It has been suggested that serial dependence might be particularly strong when the stimuli are relatively ambiguous with respect to the judgment to be made (Cicchini et al., 2018). It is proposed that this effect occurs because serial dependence works to increase the efficiency of our visual system and reduce overall noise (Cicchini et al., 2018). Serial dependence bias has been observed in the evaluation of a number of different stimuli, such as number (Fornaciai and Park, 2018), orientation (Fischer and Whitney, 2014; John-Saaltink et al., 2016), facial identity (Liberman et al., 2014), attractiveness (Xia et al., 2016), and gender (Taubert et al., 2016), and recently, in body size estimation (Alexi et al., 2018, 2019).

Importantly, serial dependence bias has recently been shown to be associated with eating disorder symptomatology (Alexi et al., 2019). However, this association was found using real body images. We do not know whether the same pattern of results would be evident with CG bodies. Previous research has highlighted the importance of social comparisons of oneself to other individuals' bodies in predicting body image disturbances (Stormer and Thompson, 1996; Ridolfi et al., 2011). Given the reduced realism of CG body stimuli that is highlighted in the face perception literature, it is possible that the impoverished visual information might impact humans' abilities to relate to CG stimuli in the same way that has been evidenced in social comparison research. If this were the case, the relationship between serial dependence and eating disorder symptoms would likely be underestimated. Alternatively, it may be that the distinction between CG and real body images is less imperative in body judgments (e.g., Cornelissen et al., 2015, 2016) than it is in other areas (e.g., Crookes et al., 2015), in which case we would expect to see a retention of the significant relationship previously observed between serial dependence and eating disorder symptoms (Alexi et al., 2019).

In order to examine the efficacy of CG body stimuli in the study of body size judgments and their biases, we utilized an established bodyline task (Alexi et al., 2018) for measuring body size estimation and the two aforementioned biases, but we modified the task by presenting CG body stimuli. While there have been some alternative findings in the literature regarding CG and real comparisons, the majority of research in CG imagery seems to indicate that there are subtle differences in the detection and judgment of CG compared to real images, with textural elements noted to play a role (Johnson et al., 2011; Tinwell et al., 2011; Balas and Pacella, 2015, 2017; Crookes et al., 2015). It seems reasonable to predict that textural information is also important in body perception, particularly so for extreme body sizes. For example, key body weight markers, such as visible bone structures in emaciation, or cellulite in obesity appear difficult to fully represent using synthetic textures. Therefore, we hypothesized that perception of CG body stimuli would be non-linear, with poor discrimination among extreme weight categories. Poorer discrimination is also predicted to result in larger body size estimation biases, namely regression to the mean and serial dependence (Alexi et al., 2018). Secondly, although speculative and assuming that our initial hypothesis is satisfied, we formed the intuitive hypothesis that CG body stimuli would reduce self-referencing abilities and result in a diminished relationship between serial dependence and eating disorder symptoms.

METHOD

The current study was approved by the Human Research Ethics Committee of the University of Western Australia and completed in accordance with their rules, guidelines, and regulations. Participation was entirely voluntary and helped to form a component of participants' undergraduate course credit. All participants provided written informed consent prior to completing the experiment and were debriefed in full following completion of the experiment. Additionally, this study was completed in parallel to the Alexi et al. (2018) study, which established serial dependencies in body size estimations using the bodyline task with real bodies. Therefore, the same sample of participants from Alexi et al. (2018) completed the tasks in the current study.

Participants

One hundred and six female undergraduate psychology students from The University of Western Australia participated in the study. Two participants' data were removed due to failure to follow the task instructions. A third participant's data were removed due to a computer malfunction. Therefore, the analyses outlined below were completed using the remaining participants' data ($N = 103$). The age of the participants ranged from 17 to 25 years ($M = 18.88$, SD = 1.65) and participants' BMI ranged from 16.23 to 43.99 ($M = 22.22$, SD = 3.93). We restricted our sample to females aged between 17 and 25 due to the high prevalence of eating disorders in this sample (The Butterfly Foundation, 2012).

Materials

Stimuli

Each of the CG body images was created on computer-generated (CG) software, Poser version 11 (Smith Micro Software, 2015). Poser software was utilized in the current study for consistency with previous research that regularly employed this software to develop body stimuli (e.g., Glauert, 2008; Nikkelen et al., 2012; Cho and Lee, 2013). Poser software contains multiple body weight dials, such as the "thin" or "heavy" dials, which can be reduced or increased incrementally when creating body stimuli. Adjusting these dials alters the body weight and size of a chosen CG figure consistent with the descriptor of the dial. The dials "thin," "emaciated," "heavy," and "rubenesque" were chosen for creating our CG body stimuli as they were the most relevant dials to use and produced body types and sizes most consistent with previously established real body images (Alexi et al., 2018).

Pilot Study to Calibrate Size Range of Computer-Generated Stimuli to Prior Real Body Images

In our earlier work involving real body images, we presented size body size categories (Alexi et al., 2018, 2019). We decided to design CG stimuli that covered the same overall size range as in our previous work. Accordingly, we used Poser software (Smith Micro Software, 2015) to create two sets of CG body images; the first set of three images represented thin endpoint (category 1) real body images and the second set of three matched the heavy (category 7) real body images used by Alexi et al. (2018, 2019). Each set of three body images varied slightly in weight, yet still remained representative of their respective category. We manipulated the "thin" and "emaciated" dials to create the category 1 representative body images. In contrast, the "heavy" and "rubenesque" dials were adjusted to form the category 7 representative body images. Each of the CG body images was created using the CG model "Alyson." The body images were clothed in underwear in order to match previous body images (Alexi et al., 2018, 2019) and permit view of key body weight markers (e.g., hollowing skin, cellulite etc.).

Using the abovementioned CG body images, a pilot study with five participants was conducted to establish the best matching CG endpoint body categories 1 and 7, with respect to the real body endpoint categories from Alexi et al.'s (2018) study. Participants were first shown the three exemplar category 1 CG body stimuli and each of the five real category 1 bodies used by Alexi et al. (2018). Participants were then asked to choose which of the three CG body stimuli best matched the real category 1 bodies. Using this same methodology, participants then selected the closest CG match to the real category 7 body images.

Creation of the Computer-Generated Body Continuum

Using the data from our pilot study, the best matched category 1 and 7 CG body images (and body weight dial values) were determined. This selection was based on an inter-rater agreement of ≥60%. Following selection of the best matched category 1 and 7 CG bodies, the rest of the full body continuum was created in Poser (Smith Micro Software, 2015). This was done by varying the dial values, as determined by the pilot study, in equal linear steps along the continuum. As the dials "thin" and "heavy" were considered exact opposites of the body weight continuum, we used the difference value between the "thin" and "heavy" dials to divide the two dials into equal increments along the body continuum. The "emaciated" and "rubenesque" dials were also considered to reside on opposite ends of the body weight continuum. Therefore, we applied the above method to the "emaciated" and "rubenesque" dials. Hence, the final CG body continuum resulted in the use of the "thin" and "emaciated" dials for the "thinner" end of the CG body continuum (categories 1 to 3) and then transitioned into the use of the "heavy" and "rubenesque" dials for the "heavier" end of the CG body continuum (categories 4 to 7). The two sets of dials ("thin" and "heavy" and "emaciated" and "rubenesque") increased in equal linear steps along their respective ends of the continuum, which resulted in a continuous transition from thin to heavy.

Once each of the seven body category dial values had been determined using the above methodology, we created the rest of the CG body image database. This resulted in the creation of 35 CG body images (five images per category) for use in the bodyline task. These body images ranged from extremely underweight to extremely overweight, along the body continuum. The total number of CG body images and body categories were chosen to match the prior real body image database (Alexi et al., 2018, 2019).

We ensured that our set of CG body images matched the previously established and validated real body images (see Alexi et al., 2018) on identity and clothing, where possible. We did this by giving the final CG body images' variations in pose and clothing to closely match prior research (Alexi et al., 2018, 2019). While we varied the skin tones of the CG bodies, we used the same model type (model "Alyson") for each of the CG body stimuli. This allowed each of the CG body images to represent a unique identity, and match, as close as possible, the real body images first used in Alexi et al. (2018). As in that study, the images were cropped on Adobe Photoshop to display the whole body but omit the face. The omission of face stimuli in this experiment was deliberately implemented to ensure that the attractiveness of the stimuli did not bias

FIGURE 1 | Example CG body image categories from one (left) to seven (right), which were used in the CG bodyline task. The depicted body images were created with CG imagery software, Poser Version 11 (Smith Micro Software, 2015).

participants' judgments of size. See **Figure 1** for an example of the final seven CG body image categories.

Six CG body anchors (three of which represented an extremely underweight body anchor and three of which represented an extremely overweight body anchor) were also generated in Poser (Smith Micro Software, 2015) using the "thin" and "emaciated" and "heavy" and "rubenesque" dials, respectively. These body anchors were generated to match the previously established real body anchors on size (Alexi et al., 2018) and to be used as off-scale body anchors denoting the two ends of the visual analogue scale in the bodyline task. They were created to be more extreme in weight than any of the CG body categories, analogous to the real body image database (Alexi et al., 2018). Using the same methodology as in our pilot study, the same five participants were asked to select which one of the three extremely underweight and extremely overweight CG body anchors best matched the real body anchors. The final CG body anchors were selected based on inter-rater agreement of >60%. The CG body anchors were also matched to the real body anchors on identity, clothing, pose, and stance.

Eating Disorder Examination – Questionnaire 6.0

The Eating Disorder Examination – Questionnaire 6.0 (EDE-Q) is a self-report eating and weight behaviors questionnaire, which was based on the original interview format questionnaire (Fairburn and Beglin, 1994). The EDE-Q comprises 28 items in total, 22 items of which explore overall attitudinal components of eating disorder symptomatology (Mond et al., 2004). The 22 items form the subscales of Restraint (5 items), Eating Concern (5 items), Weight Concern (5 items), and Shape Concern (8 items). Restraint and Eating Concern subscales measure abnormal eating behaviors, while Weight and Shape Concern subscales examine negative body image, across the preceding 28-day period (Hilbert et al., 2012). Respondents answer across a 7-point, forced choice, Likert rating scale (0 = *complete absence of feature* to 6 = *acute presentation of feature*) (Hilbert et al., 2012). The remaining six items measure information relevant for diagnosing an eating disorder, such as self-induced vomiting. Reliability and validity of the EDE-Q are well established (Mond et al., 2004, 2006). The Cronbach's alphas for the EDE-Q in our sample were: 0.80 (Dietary Restraint), 0.77 (Eating Concern), 0.91 (Shape Concern), and 0.84 (Weight Concern).

Procedure

Participants were seated in a quiet room facing a computer screen, keyboard, and mouse, which the experiment was completed with. The experiment was conducted on an Asus branded PC running Matlab (The MathWorks Inc., 2013) and the Psychophysics Toolbox (Brainard, 1997). The CG body stimuli were shown on a Viewpixx branded PC monitor with a resolution, size, and luminance consistent with the previous "bodyline" study by Alexi et al. (2018). The size and contrast of the stimuli were also consistent with Alexi et al. (2018).

Participants were given instructions regarding the experiment and were then asked to read an information sheet and sign the corresponding consent form. All participants gave written informed consent and were instructed in detail prior to completing the experimental tasks. Following this, participants completed an established bodyline task, which has been shown to measure both, regression to the mean and serial dependence biases (Alexi et al., 2018). The bodyline task in this experiment was adapted to consist of the CG body images created for this experiment.

During the bodyline task, participants were required to judge the weight of various body stimuli, ranging from underweight through average-weight to overweight, using a continuous visual analogue scale (VAS). Participants recorded their responses by left-clicking the mouse along the VAS at the bottom of the screen. The VAS was an unmarked line scored linearly from 1.0 to 7.0, and was present throughout the bodyline task. A CG anchor body image was presented beyond each end of the bodyline scale, demarcating the two extreme weights: extremely underweight and extremely overweight. These anchors were more extreme than any of the body images shown throughout the experiment.

Participants first completed 14 practice trials, followed by three blocks of 50 trials. Body stimuli were presented in a fixed order across all subjects, identical to the order presented by Alexi et al. (2018, 2019). Each of the body images were presented for 250 ms, followed by a random-noise mask, comprised of scrambled fragments of the CG body images, for 500 ms. The noise mask was implemented to interrupt visual processing of the stimuli and to prompt participants for a response. See **Figure 2** for a visual depiction of the bodyline task. Upon completion of the bodyline task, participants completed the EDE-Q. Participants' own height and weight were then measured in order to obtain an estimate of participants' Body Mass Index (BMI).

RESULTS

The results section first includes a description of the data cleaning process. Secondly, we outline the bodyline, regression to the mean and serial dependence data to provide an examination of our main hypothesis. We then go on to examine our second hypothesis by reporting the correlational analysis between our two perceptual biases and EDE-Q. The data from our pilot study and main results were analyzed using SPSS statistical software and Graphpad Prism software.

Data Cleaning and Outlier Removal Process

Before data analysis, the EDE-Q and BMI variables were screened for normality using the criteria of skew < |2.00| and kurtosis < |7.00| (Curran et al., 1996). Using these guidelines, our EDE-Q variable was associated with an appropriate level of normality for the purposes of our analyses. However, our BMI variable was associated with a high level of skew (2.19) and kurtosis (8.87), which appeared to be driven by an outlier. Therefore, we analyzed the BMI variable using the outlier criterion method of three standard deviations above and below the mean (Howell, 1998).

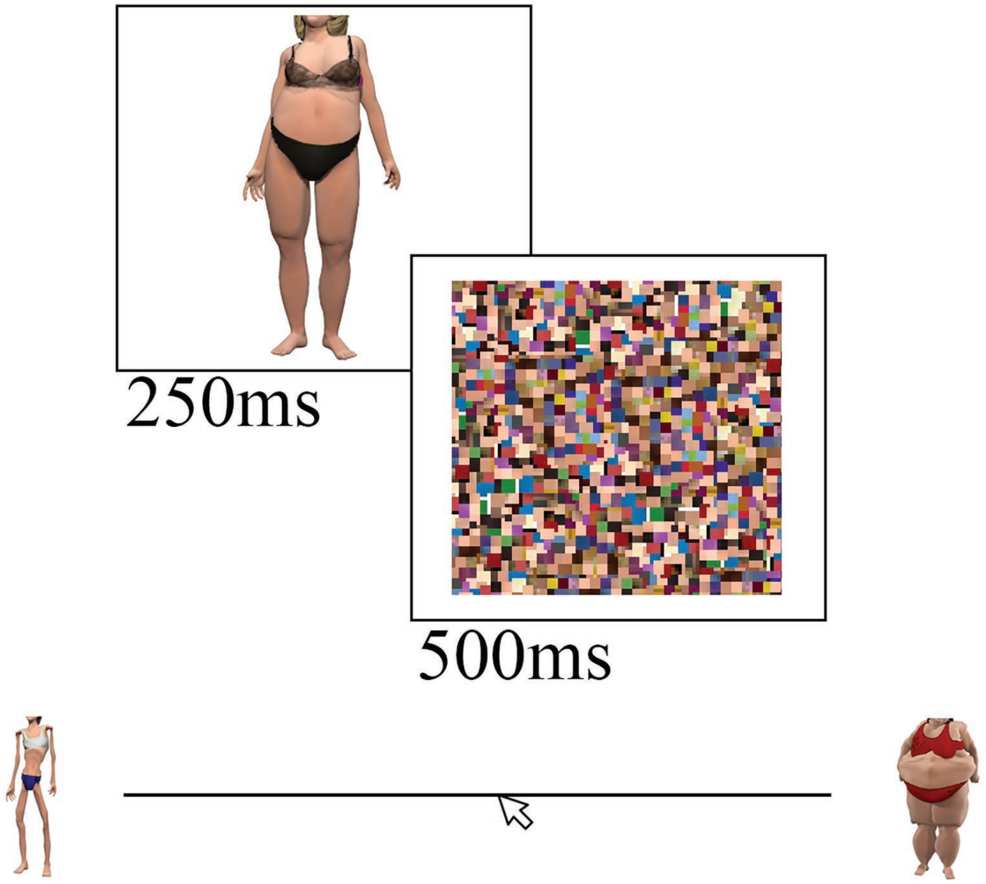

FIGURE 2 | A visual representation of the CG bodyline task. The bodyline task required participants to judge the size of CG body stimuli that were presented for 250 ms, followed by a visual noise mask for 500 ms. Participants recorded their body size estimations by left-clicking their mouse along the bodyline, which showed an extreme body anchor displaced from each end of the scale. The anchor images were more extreme in size than all of the body images presented throughout the bodyline task. The bodyline was continuously presented throughout the task. The body images presented here were shown in the experiment and were created using CG imagery software, Poser (Smith Micro Software, 2015).

TABLE 1 | Descriptive statistics associated with participant BMI and EDE-Q subscale and global scores.

	BMI	EDE-Q R	EDE-Q EC	EDE-Q SC	EDE-Q WC	EDE-Q G
M	22.12	1.43	1.00	2.54	2.16	1.78
SD	3.48	1.26	1.02	1.49	1.51	1.17
Min.	16.23	0	0	0	0	0
Max.	33.73	5.40	5.40	6.00	5.60	5.40

M, mean; SD, standard deviation; EDE-Q R, Eating Disorder Examination Questionnaire Restraint Subscale; EDE-Q EC, Eating Disorder Examination Questionnaire Eating Concern Subscale; EDE-Q SC, Eating Disorder Examination Questionnaire Shape Concern Subscale; EDE-Q WC, Eating Disorder Examination Questionnaire Weight Concern Subscale; EDE-Q G, Eating Disorder Examination Questionnaire Global Score.

Using this criterion, one outlier was identified and subsequently winsorized (Reifman and Keyton, 2010; Ghosh and Vogt, 2012). Following revision of the outlier through winsorizing processes, skew and kurtosis of the BMI variable were reduced to 1.16 and 1.87, respectively. See **Table 1** for revised BMI descriptive statistics.

Computer-Generated Body Size Estimation and Regression to the Mean

In order to address our main hypothesis regarding the judgment of CG body stimuli, we first report the mean body size judgments of each category when participants were presented with CG body stimuli (see **Figure 3**). These data relate to our first perceptual bias, regression to the mean. In the next section, we will report on the other perceptual bias, serial dependence.

The pattern of responses in the CG bodyline data appears to be a non-linear sigmoidal shape (see **Figure 3**). Visually, this is reflected by smaller perceived size changes between categories 1–3 and 5–7, while there is a disproportionately large perceived size change between categories 3 and 5. This non-linear interpretation is supported numerically and statistically. Numerically, we note that 56% of the scale is being used to represent the size change across near to average size bodies (categories 3–5) while only 44% of the scale is used to represent the size change across the remaining body categories, despite being double in number and bearing in mind that

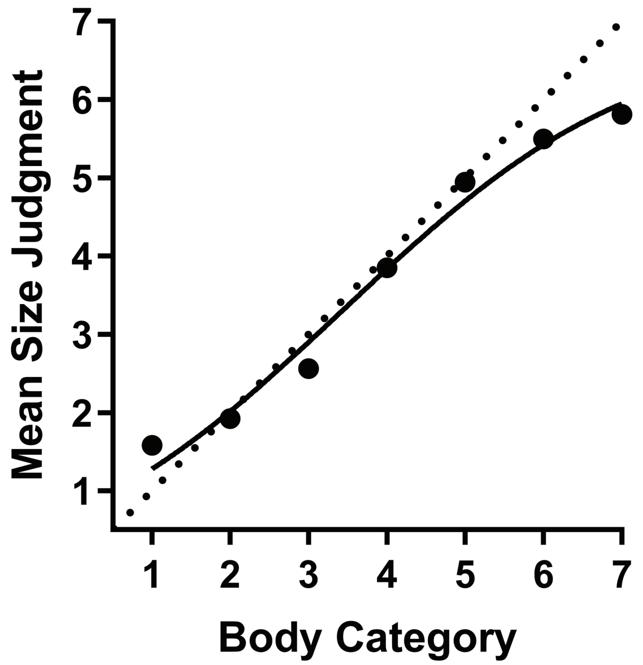

FIGURE 3 | Visual depiction of the bodyline task data for CG body images. Data show average body size judgments across the seven body image categories. The dotted diagonal line shows unbiased, veridical judgment of the body categories. Error bars depicting SEM are plotted.

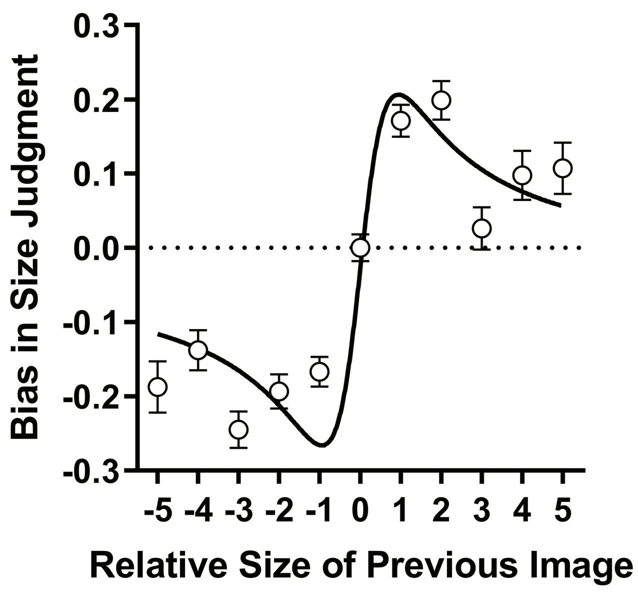

FIGURE 4 | Serial dependence bias in body size estimation using CG body images. The data display the average bias in the perceived size (difference between perceived and physical size of the body images), as a function of the size of the previously viewed body image. Error bars depict ± 1 SEM. The solid black curve demonstrates the prediction of the unconstrained Kalman-filter model described in Alexi et al. (2018). The dotted horizontal line shows zero bias in size judgments.

we specifically constructed uniform, linear increments across categories, in Poser. Statistically, the non-linear trend of the data was confirmed by a comparison of fits analysis. This analysis compared a linear fit, as per Alexi et al. (2018), and a non-linear (Cumulative Gaussian) fit, to the CG bodyline data. The analysis revealed statistical support for a non-linear fit, $F(1, 718) = 112.6$, $p < 0.0001$. Finally, we note that the non-linear fit was an excellent fit to the data ($R^2 = 0.91$). We conclude then that the estimation of body size for CG bodies created by our Poser methods is non-linear.

Next we consider the strength of the regression to the mean bias for CG bodies. Fitting a linear regression slope to the bodyline data can provide an estimate of a regression to the mean bias if the slope observed is less than 1.0 (assumed as veridical perception) (Alexi et al., 2018). Applying a linear fit to the CG body data also produced data consistent with regression to the mean (Slope = 0.79, 95% CI: 0.63–0.96). However, since a linear fit is not appropriate for the CG data, this estimate may be problematic to interpret in relation to other regression to the mean estimates.

Computer-Generated Body Size Estimation and Serial Dependence

As the second part of our main hypothesis, we investigated the presence of serial dependence for CG body stimuli. Serial dependence was calculated in accordance with the procedures outlined by Alexi et al. (2018). **Figure 4** plots the average bias in body size judgments (i.e., the difference between responses and physical stimuli) along the vertical axis, as a function of the size difference of the previously viewed body image, along the horizontal axis. As would be expected, no bias was found for trials where the previously seen body was the same category as the current body (location zero on both, horizontal and vertical axes). Note, data residing on the dotted horizontal line indicated unbiased or veridical body size perception. As can be seen, the CG body data were consistent with serial dependence. That is, participants' size estimates were biased toward the previously seen body. Specifically, participants were biased to see bodies as thinner than they actually were when they were preceded by thinner body images (see lower left quadrant of **Figure 4**) and the reverse was true for the larger body categories (see upper right quadrant of **Figure 4**). The CG body data were well fit ($R^2 = 0.86$) by a Kalmann-Filter model, as used by Alexi et al. (2018).

Correlational Findings Between Body Size Biases and Eating Disorder Examination – Questionnaire 6.0

Lastly, we examined our final hypothesis, relating to whether the biases observed in the CG body data were associated with EDE-Q. See **Table 1** for the descriptive statistics associated with participant EDE-Q subscale and global scores.

We report the correlational findings in the order that we presented the body size biases above. A partial correlation was first conducted between participants' regression index (i.e., participants' magnitude of regression to the mean bias) and their associated global EDE-Q score, controlling for BMI. Participant regression indexes were determined using the same methodology as first described by Alexi et al. (2018). The correlation in this study revealed a non-significant association, $r(100) = -0.16$, $p = 0.120$, suggesting a non-significant relationship between regression to the mean bias and eating disorder symptomatology.

Next, we conducted a partial correlation analysis between participants' magnitude of serial dependence and global EDE-Q, while controlling for BMI. The results from this partial correlation yielded a non-significant association, $r(100) = -0.01$, $p = 0.903$. In a previous study by Alexi et al. (2019) who used real body stimuli, a significant association between serial dependence magnitude and global EDE-Q was found [$r(59) = 0.28$, $p < 0.05$]. The discrepancy in findings between Alexi et al.'s (2019) findings and our current research may well be explained by the use of the CG body stimuli. The interpretation of this result is framed within the context of reduced self-comparisons for CG bodies in the "Discussion" section below.

DISCUSSION

The current study investigated body size estimations of CG body stimuli. We firstly hypothesized that the perception of sizes of CG bodies would be non-linear, leading to increased perceptual biases, namely regression to the mean and serial dependence. Secondly, we did not expect to find a significant correlation between serial dependence magnitude and eating disorder symptoms when judging CG body images, due to the hypothesized importance of self-reference when judging bodies.

Our findings provided support for our first hypothesis, by showing non-linear body size estimation when participants judged CG body images. The non-linear pattern of the CG bodyline data makes it problematic to provide a sensible estimate of regression to the mean using the traditional linear slope analysis. We can say, however, that as predicted, participants clearly found it difficult to discriminate between the more extreme CG size categories (i.e., categories 1–3 and 5–7), compared to the same real body categories in our previously published work (Alexi et al., 2018), which showed linear discrimination. This finding accords with previous research showing that discrimination and recognition of faces is also significantly reduced for CG faces (Crookes et al., 2015). Therefore, we take the results of our CG bodyline task to suggest that the use of CG body stimuli reduces discriminability between body categories. We hypothesize that this is due to the impoverished representation of textural elements in CG body stimuli. For instance, the smoothing functions in CG Poser software do not well represent the subtle textural differences in skin, such as cellulite, hollowing skin surfaces, or visible bones, which observers may use as markers of body weight.

We should point out that two other studies (i.e., Tovée et al., 2012; Cornelissen et al., 2016) that compared the use of real and CG bodies reached alternative conclusions to the current study, as described in the "Introduction" section. This discrepancy in findings may be a result of the type of judgment asked of participants in Tovée et al.'s (2012) study or may reflect a lack of sensitivity to the differences in CG and real bodies by using differing BMI ranges to compare performance, as was done in Cornelissen et al.'s (2016) study. Alternatively, as previously suggested, it may be that the specific software we used here resulted in stimuli that do not represent body size changes as precisely as other versions or software used in these other studies.

Analysis of the second perceptual bias, serial dependence, provided strong support for our main hypothesis. We found that the serial dependence bias for CG body images was up to 50% larger than the size of the serial dependence effect demonstrated by Alexi et al. (2018) for real body images. This finding can likely be explained by the conditions that are known to increase serial dependence biases. Specifically, serial dependence works to stabilize perception of ambiguous stimuli/scenes, resulting in largest serial dependencies when there is high stimulus uncertainty (Cicchini et al., 2018). Considering that our data suggest poorer (non-linear) discrimination for CG bodies compared to real bodies, we would expect this to manifest in larger serial dependencies for CG than real bodies (Cicchini et al., 2018). Our finding of a larger serial dependence bias for CG bodies accords with this view and is consistent with previous findings (Cicchini et al., 2018). This result signals the importance of using CG body stimuli with caution, as they are more poorly discriminated between than real bodies and participants show larger errors, in the form of larger serial dependence biases, when judging their size.

We next examined the association between the two measured perceptual biases and eating disorder symptomatology. We found no evidence for an association between regression to the mean and eating disorder symptoms. This finding corroborates previous findings by Cornelissen et al. (2015), who found that psychological symptoms had an effect on the overall magnitude of judgments but not the gradient of judgments (i.e., regression to the mean). However, critically, our results showed that eating disorder symptoms were also not significantly related to serial dependence bias for CG bodies. This finding is of particular interest, considering recent evidence for a significant association between eating disorder symptomatology and serial dependence bias for real body images (Alexi et al., 2019). One possible explanation for the absence of such a relationship in the perception of CG bodies is that this stimulus class may have reduced participant self-comparison to their own bodies. Social comparison theory suggests that individuals compare themselves to others in order to make judgments about their own characteristics (Bessenoff, 2006; Franzoi et al., 2011). In fact, a study conducted by Stormer and Thompson (1996) found that social comparison to others' bodies was a fundamental contributor to bodily dissatisfaction. Therefore, it is possible that the use of CG bodies led to a reduction in the comparisons of oneself to the CG body images, which may have consequently diminished the effect of individual differences in serial dependence. Together, the correlational findings observed in serial dependence provides support for our second hypothesis as it shows a diminished relationship between EDE-Q and body size biases for CG bodies.

We offer two likely explanations for our collective findings of poorer discrimination and increased errors in the body size estimation of CG bodies. Firstly, as we and others (Crookes et al., 2015) have proposed, poorer discrimination for CG stimuli may reflect an objective lack of relevant feature information in this stimulus. Research has shown that despite the element of realism that CG imagery can generate, observers are still able to identify a CG image from a real image, suggesting that CG images may be unable to fully capture the nuances of real-life stimuli (Johnson et al., 2011; Farid and Bravo, 2012). This failure to fully replicate real bodies leads to less realistic body categories. This may be particularly true for very underweight and very overweight bodies, where skin texture and detailed feature characteristics are particularly important. However, there is a fine line between CG realism and complete human-likeness (Tinwell et al., 2011). Generating CG stimuli that are hyper-realistic may result in the "uncanny valley" effect – a phenomenon whereby observers describe aversive reactions toward hyper-realistic CG characters, due to subtle oddities in their appearance (Tinwell et al., 2011). Importantly, the "uncanny valley" phenomenon demonstrates how attune observers are to the subtle variations in CG imagery, therefore highlighting the importance of providing information-rich and accurate CG body images.

Secondly, our findings may instead reflect a lack of participant exposure to, and familiarity with, CG bodies (Crookes et al., 2015). It is well known that humans develop an expertise in judging human faces (Crookes et al., 2015). Neuropsychological and imaging findings suggest that it is likely that humans develop a similar expertise for perceiving and judging bodies, which is strengthened and fine-tuned over time and with continued exposure (Downing et al., 2001; Ishizu et al., 2010; Downing and Peelen, 2016; Gillmeister et al., 2019). Given humans view real, not CG bodies, on a daily basis, it is conceivable that our results may instead reflect a reduced expertise for CG bodies. Therefore, it may be particularly important to discern whether our results reflect reduced familiarity with CG bodies or are the result of a poorer "make up" of the CG bodies used in our task (e.g., less textural information). Future studies may explore the effect that additional training and exposure to CG bodies has on the accuracy of body size judgments (Balas and Pacella, 2015). Alternatively, it may be worth comparing the accuracy of body size estimates between participants who already have substantial exposure to CG imagery (e.g., individuals who frequently play video games involving CG bodies) to those who do not.

Our results highlight the shortcomings of using CG body stimuli in body size estimation tasks. However, we acknowledge the boundaries of our findings are limited to stimuli created with Poser version 11 software. Additionally, given the fast-paced nature of technological advancements in computer graphics, it is important to keep in mind that these results may differ with the use of other Poser versions or with other CG software and in the future with more advanced technology. In fact, some of these advancements are beginning to take shape already. In particular, recent research has begun to incorporate the use of hybrid based body stimuli (Stephen et al., 2018). This stimulus type typically involves obtaining photographs of real bodies under controlled conditions (e.g., standardized lighting, clothing, and photograph angles), which are then systematically manipulated across body weight biomarkers, to create body images that vary along the body weight continuum. This type of manipulation is proposed to simulate typical body weight changes and therefore achieve more realistic transformations in fat mass than previous methods, which simply widened or "stretched" images to achieve the appearance of body weight changes (Stephen et al., 2018). Hybrid body stimuli are advantageous in that they incorporate real body images, which are ecologically sound, while also achieving standardized body weight increments, using morphing software. Additionally, new stimulus methodologies have started to incorporate the use of 3D body scanning equipment to create a mesh of participant's own bodies, which are then used to generate personalized CG body avatars (Cornelissen et al., 2017). Using this type of stimulus class may enhance ecological validity by stimulating the act of looking in a mirror when judging body size (Cornelissen et al., 2017). Three-dimensional CG body stimuli have also recently been created and used within the virtual reality context to examine body image distortions (Ferrer-Garcia et al., 2017; Serino et al., 2019). While these body images are computer-generated, they provide an increased element of realism in their three-dimensional presentation, which may better highlight certain body weight markers (e.g., stomach and thighs). Future research would benefit from understanding whether these stimuli types are more ecologically valid and efficacious than traditional CG stimuli.

In conclusion, the current study examined the effect of CG body images on body size estimation and their associated estimation biases: regression to the mean and serial dependence. Our results suggested poorer discriminability among the CG bodies and larger body size judgment errors, which were demonstrated by larger serial dependencies. Taken together, our results highlight the importance of using caution when employing CG body stimuli in the study of body size estimation and its biases. Furthermore, our findings suggest that care should be taken when interpreting the findings of studies that do use CG bodies. Our combined findings provide useful information to researchers seeking to develop experimental tasks that require the use of body images.

DATA AVAILABILITY STATEMENT

The datasets created and analyzed during the current research are available from the corresponding author on request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Human Research Ethics Committee of the University of Western Australia. The patients/participants provided their written informed consent to participate in this study. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

JA, JB, RP, and NK designed the study. Testing and data collection were performed by JA, KD, and DC. JA and JB analyzed the data and drafted the manuscript. All authors provided critical revisions and approved the final manuscript for submission.

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REFERENCES

Alexi, J., Cleary, D., Dommisse, K., Palermo, R., Kloth, N., Burr, D., et al. (2018). Past visual experiences weigh in on body size estimation. *Sci. Rep.* 8, 1–8. doi: 10.1038/s41598-017-18418-3

Alexi, J., Palermo, R., Rieger, E., and Bell, J. (2019). Evidence for a perceptual mechanism relating body size misperception and eating disorder symptoms. *Eat. Weight Disord.* 24, 615–621. doi: 10.1007/s40519-019-00653-4

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders.* 5th Edn. Washington, DC: American Psychiatric Association.

Balas, B., and Pacella, J. (2015). Artificial faces are harder to remember. *Comput. Hum. Behav.* 52, 331–337. doi: 10.1016/j.chb.2015.06.018

Balas, B., and Pacella, J. (2017). Trustworthiness perception is disrupted in artificial faces. *Comput. Hum. Behav.* 77, 240–248. doi: 10.1016/j.chb.2017.08.045

Bell, C., Kirkpatrick, S. W., and Rinn, R. C. (1986). Body image of anorexic, obese, and normal females. *J. Clin. Psychol.* 42, 431–439. doi: 10.1002/1097-4679(198605)42:3<431::AID-JCLP2270420305>3.0.CO;2-I

Bessenoff, G. R. (2006). Can the media affect us? Social comparison, self-discrepancy, and the thin ideal. *Psychol. Women Q.* 30, 239–251. doi: 10.1111/j.1471-6402.2006.00292.x

Blechert, J., Ansorge, U., and Tuschen-Caffier, B. (2010). A body-related dot-probe task reveals distinct attentional patterns for bulimia nervosa and anorexia nervosa. *J. Abnorm. Psychol.* 119, 575–585. doi: 10.1037/a0019531

Brainard, D. H. (1997). The psychophysics toolbox. *Spat. Vis.* 10, 433–436. doi: 10.1163/156856897X00357

Cash, T. F., and Deagle, E. A. (1997). The nature and extent of body-image disturbances in anorexia nervosa and bulimia nervosa: a meta-analysis. *Int. J. Eat. Disord.* 22, 107–126. doi: 10.1002/(SICI)1098-108X(199709)22:2<107::AID-EAT1>3.0.CO;2-J

Cho, A., and Lee, J. H. (2013). Body dissatisfaction levels and gender differences in attentional biases toward idealized bodies. *Body Image* 10, 95–102. doi: 10.1016/j.bodyim.2012.09.005

Cicchini, G. M., Mikellidou, K., and Burr, D. C. (2018). The functional role of serial dependence. *Proc. R. Soc. B Biol. Sci.* 285:20181722. doi: 10.1098/rspb.2018.1722

Cornelissen, K., Bester, A., Cairns, P., Tovée, M., and Cornelissen, P. (2015). The influence of personal BMI on body size estimations and sensitivity to body size change in anorexia spectrum disorders. *Body Image* 13, 75–85. doi: 10.1016/j.bodyim.2015.01.001

Cornelissen, K., Gledhill, L., Cornelissen, P., and Tovée, M. (2016). Visual biases in judging body weight. *Br. J. Health Psychol.* 21, 555–569. doi: 10.1111/bjhp.12185

Cornelissen, K., Mccarty, K., Cornelissen, P., and Tovée, M. (2017). Body size estimation in women with anorexia nervosa and healthy controls using 3D avatars. *Sci. Rep.* 7:15773. doi: 10.1038/s41598-017-15339-z

Crookes, K., Ewing, L., Gildenhuys, J.-D., Kloth, N., Hayward, W. G., Oxner, M., et al. (2015). How well do computer-generated faces tap face expertise? *PLoS One* 10:e0141353. doi: 10.1371/journal.pone.0141353

Curran, P. J., West, S. G., and Finch, J. F. (1996). The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. *Psychol. Methods* 1, 16–29. doi: 10.1037/1082-989X.1.1.16

Dondzilo, L., Rieger, E., Jayawardena, N., and Bell, J. (2018). Drive for thinness versus fear of fat: approach and avoidance motivation regarding thin and non-thin images in women. *Cogn. Ther. Res.* 43, 585–593. doi: 10.1007/s10608-018-9989-3

Downing, P. E., Jiang, Y., Shuman, M., and Kanwisher, N. (2001). A cortical area selective for visual processing of the human body. *Science* 293, 2470–2473. doi: 10.1126/science.1063414

Downing, P. E., and Peelen, M. V. (2016). Body selectivity in occipitotemporal cortex: causal evidence. *Neuropsychologia* 83, 138–148. doi: 10.1016/j.neuropsychologia.2015.05.033

Eshkevari, E., Rieger, E., Longo, M. R., Haggard, P., and Treasure, J. (2014). Persistent body image disturbance following recovery from eating disorders. *Int. J. Eat. Disord.* 47, 400–409. doi: 10.1002/eat.22219

Fairburn, C., and Beglin, S. J. (1994). Assessment of eating disorders: interview or self-report questionnaire? *Int. J. Eat. Disord.* 16, 363–370.

Fan, S., Ng, T.-T., Herberg, J. S., Koenig, B. L., and Xin, S. (2012). "Real or fake?: human judgments about photographs and computer-generated images of faces" in *SIGGRAPH Asia 2012 technical briefs. Vol. 17* (New York, USA: Association for Computing Machinery), 1–4.

Fan, S., Wang, R., Ng, T.-T., Tan, C., Herberg, J., and Koenig, B. (2014). Human perception of visual realism for photo and computer-generated face images. *ACM Trans. Appl. Percept.* 11, 1–21. doi: 10.1145/2620030

Farid, H., and Bravo, M. J. (2012). Perceptual discrimination of computer generated and photographic faces. *Digit. Investig.* 8, 226–235. doi: 10.1016/j.diin.2011.06.003

Ferrer-Garcia, M., Porras-Garcia, B., González-Ibañez, C., Gracia-Blanes, M., Vilalta-Abella, F., Pla-Sanjuanelo, J., et al. (2017). Does owning a "fatter" virtual body increase body anxiety in college students? *Annu. Rev. Cyberther. Telemed.* 15, 147–153.

Fischer, J., and Whitney, D. (2014). Serial dependence in visual perception. *Nat. Neurosci.* 17, 738–743. doi: 10.1038/nn.3689

Fornaciai, M., and Park, J. (2018). Serial dependence in numerosity perception. *J. Vis.* 18:15. doi: 10.1167/18.9.15

Franzoi, S. L., Vasquez, K., Sparapani, E., Frost, K., Martin, J., and Aebly, M. (2011). Exploring body comparison tendencies: women are self-critical whereas men are self-hopeful. *Psychol. Women Q.* 36, 99–109. doi: 10.1177/0361684311427028

Gardner, R. M., and Brown, D. L. (2014). Body size estimation in anorexia nervosa: a brief review of findings from 2003 through 2013. *Psychiatry Res.* 219, 407–410. doi: 10.1016/j.psychres.2014.06.029

Gaudio, S., Brooks, S. J., and Riva, G. (2014). Nonvisual multisensory impairment of body perception in anorexia nervosa: a systematic review of neuropsychological studies. *PLoS One* 9:e110087. doi: 10.1371/journal.pone.0110087

Ghosh, D., and Vogt, A. (2012). "Outliers: an evaluation of methodologies" in *Joint statistical meetings*, 3455–3460.

Gillmeister, H., Stets, M., Grigorova, M., and Rigato, S. (2019). How do bodies become special? Electrophysiological evidence for the emergence of body-related cortical processing in the first 14 months of life. *Dev. Psychol.* 55, 2025–2038. doi: 10.1037/dev0000762

Glauert, R. (2008). Body dissatisfaction and its relationship with the perceptual effects of exposure to bodies and attentional biases toward bodies. PhD thesis. University of Western Australia.

Hilbert, A., De Zwaan, M., and Braehler, E. (2012). How frequent are eating disturbances in the population? Norms of the eating disorder examination-questionnaire. *PLoS One* 7, 1–7. doi: 10.1371/journal.pone.0029125

Howell, D. C. (1998). *Statistical methods in human sciences*. New York: Wadsworth.

Hummel, D., Rudolf, A. K., Brandi, M. L., Untch, K. H., Grabhorn, R., Hampel, H., et al. (2013). Neural adaptation to thin and fat bodies in the fusiform body area and middle occipital gyrus: an fMRI adaptation study. *Hum. Brain Mapp.* 34, 3233–3246. doi: 10.1002/hbm.22135

Ishizu, T., Amemiya, K., Yumoto, M., and Kojima, S. (2010). Magnetoencephalographic study of the neural responses in body perception. *Neurosci. Lett.* 481, 36–40. doi: 10.1016/j.neulet.2010.06.047

John-Saaltink, E. S., Kok, P., Lau, H. C., and De Lange, F. P. (2016). Serial dependence in perceptual decisions is reflected in activity patterns in primary visual cortex. *J. Neurosci.* 36, 6186–6192. doi: 10.1523/JNEUROSCI.4390-15.2016

Johnson, M. K., Dale, K., Avidan, S., Pfister, H., Freeman, W. T., and Matusik, W. (2011). CG2Real: improving the realism of computer generated images using a large collection of photographs. *IEEE Trans. Vis. Comput. Graph.* 17, 1273–1285. doi: 10.1109/TVCG.2010.233

Lewer, M., Nasrawi, N., Schroeder, D., and Vocks, S. (2016). Body image disturbance in binge eating disorder: a comparison of obese patients with and without binge eating disorder regarding the cognitive, behavioral and perceptual component of body image. *Eat. Weight Disord.* 21, 115–125. doi: 10.1007/s40519-015-0200-5

Liberman, A., Fischer, J., and Whitney, D. (2014). Serial dependence in the perception of faces. *Curr. Biol.* 24, 2569–2574. doi: 10.1016/j.cub.2014.09.025

Mohr, H. M., Rickmeyer, C., Hummel, D., Ernst, M., and Grabhorn, R. (2016). Altered visual adaptation to body shape in eating disorders: implications for body image distortion. *Perception* 45, 725–738. doi: 10.1177/0301006616633385

Mond, J. M., Hay, P. J., Rodgers, B., and Owen, C. (2006). Eating disorder examination questionnaire (EDE-Q): norms for young adult women. *Behav. Res. Ther.* 44, 53–62. doi: 10.1016/j.brat.2004.12.003

Mond, J. M., Hay, P. J., Rodgers, B., Owen, C., and Beumont, P. J. V. (2004). Validity of the eating disorder examination questionnaire (EDE-Q) in screening for eating disorders in community samples. *Behav. Res. Ther.* 42, 551–567. doi: 10.1016/S0005-7967(03)00161-X

Moussally, J. M., Rochat, L., Posada, A., and Van Der Linden, M. (2017). A database of body-only computer-generated pictures of women for body-image studies: development and preliminary validation. *Behav. Res. Methods* 49, 172–183. doi: 10.3758/s13428-016-0703-7

Nikkelen, S. W. C., Anschutz, D. J., Ha, T., and Engels, R. C. M. E. (2012). Influence of visual attention on male body dissatisfaction after idealized media exposure. *Psychol. Men Masculinity* 13, 308–323. doi: 10.1037/a0024942

Reifman, A., and Keyton, K. (2010). Winsorize. *Encycl. Res. Des.* 3, 1636–1638. doi: 10.4135/9781412961288.n502

Ridolfi, D., Myers, T., Crowther, J., and Ciesla, J. (2011). Do appearance focused cognitive distortions moderate the relationship between social comparisons to peers and media images and body image disturbance? *Sex Roles* 65, 491–505. doi: 10.1007/s11199-011-9961-0

Riva, G., and Dakanalis, A. (2018). Altered processing and integration of multisensory bodily representations and signals in eating disorders: a possible path toward the understanding of their underlying causes. *Front. Hum. Neurosci.* 12, 1–7. doi: 10.3389/fnhum.2018.00049

Serino, S., Polli, N., and Riva, G. (2019). From avatars to body swapping: the use of virtual reality for assessing and treating body-size distortion in individuals with anorexia. *J. Clin. Psychol.* 75, 313–322. doi: 10.1002/jclp.22724

Skrzypek, S., Wehmeier, P. M., and Remschmidt, H. (2001). Body image assessment using body size estimation in recent studies on anorexia nervosa. A brief review. *Eur. Child Adolesc. Psychiatry* 10, 215–221. doi: 10.1007/s007870170010

Slade, P. (1985). A review of body-image studies in anorexia nervosa and bulimia nervosa. *J. Psychiatr. Res.* 19, 255–265. doi: 10.1016/0022-3956(85)90026-3

Smith Micro Software (2015). *Poser 11: Easily create 3D character art and animation*. Aliso Viejo, CA: Smith Micro Software Inc. Available at: http://my.smithmicro.com/poser-11.html (Accessed November 02, 2015).

Stephen, I. D., Sturman, D., Stevenson, R. J., Mond, J., and Brooks, K. R. (2018). Visual attention mediates the relationship between body satisfaction and susceptibility to the body size adaptation effect. *PLoS One* 13:e0189855. doi: 10.1371/journal.pone.0189855

Stormer, S. M., and Thompson, J. K. (1996). Explanations of body image disturbance: a test of maturational status, negative verbal commentary, social comparison, and sociocultural hypothesis. *Int. J. Eat. Disord.* 19, 193–202. doi: 10.1002/(SICI)1098-108X(199603)19:2<193::AID-EAT10>3.0.CO;2-W

Sturman, D., Stephen, I. D., Mond, J., Stevenson, R. J., and Brooks, K. R. (2017). Independent aftereffects of fat and muscle: implications for neural encoding, body space representation, and body image disturbance. *Sci. Rep.* 7:40392. doi: 10.1038/srep40392

Taubert, J., Alais, D., Burr, D., Taubert, J., Alais, D., and Burr, D. (2016). Different coding strategies for the perception of stable and changeable facial attributes. *Sci. Rep.* 6, 1–7. doi: 10.1038/srep32239

Taylor, M. J., and Cooper, P. J. (1992). An experimental study of the effect of mood on body size perception. *Behav. Res. Ther.* 30, 53–58. doi: 10.1016/0005-7967(92)90096-Y

The Butterfly Foundation (2012). *Paying the price*. Australia: The economic and social impact of eating disorders in Australia. The Butterfly Foundation.

The MathWorks Inc. (2013). *MATLAB 2013*. Natick, Massachusetts: United States.

Tinwell, A., Grimshaw, M., Nabi, D. A., and Williams, A. (2011). Facial expression of emotion and perception of the Uncanny Valley in virtual characters. *Comput. Hum. Behav.* 27, 741–749. doi: 10.1016/j.chb.2010.10.018

Tovée, M. J., Edmonds, L., and Vuong, Q. C. (2012). Categorical perception of human female physical attractiveness and health. *Evol. Hum. Behav.* 33, 85–93. doi: 10.1016/j.evolhumbehav.2011.05.008

Traub, A. C., and Orbach, J. (1964). Psychophysical studies of body-image: I. The adjustable body-distorting mirror. *Arch. Gen. Psychiatry* 11, 53–66. doi: 10.1001/archpsyc.1964.01720250055007

Vocks, S., Legenbauer, T., Ruddel, H., and Troje, N. F. (2007). Static and dynamic body image in bulimia nervosa: mental representation of body dimensions and biological motion patterns. *Int. J. Eat. Disord.* 40, 59–66. doi: 10.1002/eat.20336

Xia, Y., Leib, A. Y., and Whitney, D. (2016). Serial dependence in the perception of attractiveness. *J. Vis.* 16, 1–8. doi: 10.1167/16.15.28

Zanetti, T., Santonastaso, P., Sgaravatti, E., Degortes, D., and Favaro, A. (2013). Clinical and temperamental correlates of body image disturbance in eating disorders. *Eur. Eat. Disord. Rev.* 21, 32–37. doi: 10.1002/erv.2190

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The Thin White Line: Adaptation Suggests a Common Neural Mechanism for Judgments of Asian and Caucasian Body Size

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Visual adaptation has been proposed as a mechanism linking viewing images of thin women's bodies with body size and shape misperception (BSSM). Non-Caucasian populations appear less susceptible to BSSM, possibly because adaptation to thin Caucasian bodies in Western media may not fully transfer to own-race bodies. Experiment 1 used a cross-adaptation paradigm to examine the transfer of body size aftereffects across races. Large aftereffects were found in the predicted directions for all conditions. The strength of aftereffects was statistically equivalent when the race of test stimuli was congruent vs. incongruent with the race of adaptation stimuli, suggesting complete transfer of aftereffects across races. Experiment 2 used a contingent-adaptation paradigm, finding that simultaneous adaptation to wide Asian and narrow Caucasian women's bodies (or vice versa) results in no significant aftereffects for either congruent or incongruent conditions and statistically equivalent results for each. Equal and opposite adaptation effects may therefore transfer completely across races, canceling each other out. This suggests that body size is encoded by a race-general neural mechanism. Unexpectedly, Asian observers showed reduced body size aftereffects compared to Caucasian observers, regardless of the race of stimulus bodies, perhaps helping to explain why Asian populations appear less susceptible to BSSM.

Keywords: body perception, visual adaptation, visual aftereffects, cross-cultural, body image, body size

INTRODUCTION

Body size and shape misperception (BSSM) – a phenomenon in which some individuals overestimate or underestimate their body size – affects a large and growing segment of the population of Western countries (Powell et al., 2010; Quick et al., 2015) and is becoming increasingly common in Asian societies and around the world (Wardle et al., 2006). Body size overestimation is associated with high levels of body dissatisfaction, anxiety, and depression and is a risk factor for the development of eating disorders and compulsive exercise behaviour, particularly in young women (Griffiths et al., 2016; Bould et al., 2018). In Malaysia, a rapidly developing Southeast Asian country, 20.5% of underweight young women in a large epidemiological study overestimated their body size (Khor et al., 2009), while a large longitudinal study of young people in 24 Western countries found that over 40% of non-overweight young women overestimated their body size (Quick et al., 2015). Meanwhile, approximately a quarter of overweight (BMI > 25) women and half of overweight men misperceive themselves as having the "right weight" (Yaemsiri et al., 2011), suggesting they may be underestimating their body size. This form of BSSM may be associated with reduced motivation to lose weight (Powell et al., 2010).

Explanations for body size overestimation have typically focused on the role of the Western media's portrayal of idealized thin female bodies (Groesz et al., 2002). This connection between exposure to Western media and body image distortion is well established, with recent studies showing that the introduction of television into a region is associated with thinner ideal body size (Boothroyd et al., 2016), even when controlling for potential confounds such as nutritional status (Jucker et al., 2017). However, some evidence suggests that exposure to idealized bodies may have less pronounced effects on body dissatisfaction (which is affected by BSSM; Bould et al., 2018) for individuals of races not represented in the images (DeBraganza and Hausenblas, 2010).

Explanations for how exposure to idealized media portrayals of thin bodies leads to body image distortion have tended to focus on sociocultural mechanisms such as social comparison. However, there is evidence that mere exposure to a visual diet containing these images is sufficient to induce changes in body size preferences (Stephen and Perera, 2014) independent of cues to the social status of the individuals depicted (Boothroyd et al., 2012). Similarly, it has been suggested that body size underestimation by obese individuals may be attributable to a visual diet in which overweight and obese bodies are common, as overweight and obesity become more common in the population (Robinson and Kirkham, 2014).

Recently, it has been suggested that visual adaptation may offer a mechanism for the development of both overestimation and underestimation of body size (Mohr et al., 2016; Challinor et al., 2017; Sturman et al., 2017). Visual adaptation is a phenomenon whereby prolonged exposure to a particular stimulus (e.g., downward motion) causes adaptation of the associated neurons such that subsequently presented stimuli (stationary objects) appear to have properties opposite to those shown by the adapted stimulus (to be moving upward). These visual adaptation effects are observed in a range of low-level properties of stimuli, including orientation, color, depth, and spatial frequency (Thompson and Burr, 2009). More recently, visual adaptation has been demonstrated in higher level stimulus properties, including the identity (Rhodes et al., 2011) and gender (Yang et al., 2011) of faces, and the size and shape of bodies (Mohr et al., 2016; Sturman et al., 2017). For bodies, exposure to wide (narrow) figures causes a change in perceived size such that subsequently viewed body images appear narrower (wider) than they are (Challinor et al., 2017). Hence, the point of subjective normality (PSN) moves toward the adaptation stimulus.

For faces, the extent of visual adaptation depends in part on the race of the stimuli. Participants exposed to distorted images of faces of one race (e.g., expanded Asian faces) show an aftereffect of perceived contraction that is larger when assessed using test faces of the same race than for test faces of a different race (e.g., Caucasian faces) – a phenomenon known as partial cross-adaptation (Jaquet et al., 2008). Further, when exposed to faces of different races distorted in opposite directions (e.g., expanded Asian and contracted Caucasian faces), participants show "contingent adaptation" – simultaneous visual adaptation in both races in opposite directions (e.g., subsequently presented Asian faces appeared contracted, while Caucasian faces appeared expanded) (Jaquet et al., 2008; Gwinn and Brooks, 2013; Gwinn and Brooks, 2015a). This suggests that faces of different races are encoded by partially dissociated sets of neurons. Similar dissociations have also been demonstrated for the encoding of faces of different genders and ages (Yang et al., 2011).

Partial transfer of body size aftereffects and category-contingent body size adaptation have also been demonstrated. Brooks et al. (2016) exposed participants to adaptation stimuli with a particular identity (e.g., wide other-identity bodies), showing aftereffects of reduced magnitude when tested using stimuli with identities different to the adaptation stimuli (e.g., their own body). Furthermore, participants exposed to different-identity bodies that have been distorted in opposite directions (e.g., wide own-identity and narrow other-identity bodies) show simultaneous aftereffects in opposite directions in each body identity (e.g., own-identity bodies appear narrower and other-identity bodies appear wider than they are). This suggests that own- and other-identity bodies are encoded by partially dissociated neural populations (Brooks et al., 2016). It is not known, however, whether bodies of different races are encoded using independent or partially dissociated neural populations or a single population that is not race-sensitive. If there were no transfer of body size aftereffects, or if transfer was only partial, it may provide an explanation for the reduced effects of viewing other- (compared to own-)race bodies on observers' body dissatisfaction (DeBraganza and Hausenblas, 2010) and may shed light on the observed lower rates of body image disturbance in cultures where western media promotes the thin ideal using Caucasian models to populations of other races. For example, exposure to mainstream television (which typically features primarily white bodies) had no effect on African American women's body image, whereas exposure to black-oriented media (which typically includes black bodies and larger body sizes) improved their body image (Schooler et al., 2004).

Here, we present two experiments that aim to determine the extent of transfer of body size aftereffects across bodies of different races and thus to shed light on the nature of the neural populations encoding body size in bodies of different races. Based on the known dissociation of neural populations for the processing of facial distortion, we hypothesized that participants would show partial transfer of body size adaptation effects between bodies of different races.

METHODS

All work was approved by both the Macquarie University Human Research Ethics Committee (MUHREC), as well as the Medical Ethics Committee of the Universiti Malaysia Sabah (MECUMS). All participants gave prior, informed consent in writing.

Experiment 1

Experiment 1 used a cross-adaptation paradigm to elucidate whether the neural populations encoding body size for Asian and Caucasian identities are common or independent. Participants were exposed either to Asian or Caucasian adaptation stimuli and tested with identities from both races. If independent race-specific neural populations are used for the encoding of body size for each race, we predict that aftereffects should be demonstrated when test bodies are from the same racial group as the adaptation stimuli but absent when the adaptation and test stimuli are of different races (i.e., zero transfer of the aftereffect). Alternatively, encoding of body size by a common, race-general population would predict equivalent aftereffect magnitudes for Asian and Caucasian test identities regardless of the race of adaptation stimuli (i.e., 100% transfer). An intermediate arrangement is also possible, such that that neural populations show partial overlap. This allows us to predict aftereffects for all test bodies, but that these should be stronger for Asian compared to Caucasian test identities following adaptation to Asian adaptation identities, and vice versa (partial transfer).

Methods

Participants

One hundred and twenty-seven female participants were recruited in Australia (n = 67) and Malaysia (n = 60), giving 95% power to detect a small-medium effect size for the hypothesized race of adaptor × race of test stimulus × direction of adaptation interaction in the planned ANOVA (calculated using G*Power v3.1.9.2). Australia-based participants (M_{age} = 21.8, SD = 5.23), self-identified as Caucasian, were primarily first-year undergraduates and received course credit for their participation. Malaysia-based participants (M_{age} = 24.6, SD = 5.72), who self-identified as East/Southeast Asian, were a mix of family and friends of the researcher and students at the Universiti Malaysia Sabah and were entered into a draw to win one of three RM50 gift cards for their participation. Two Australian and four Malaysian participants were excluded from the final analysis because they did not identify as “Caucasian” (in Australia) or “East/South East Asian” (in Malaysia). Additionally, five Australian participants were excluded from the final analysis because of technical problems during their participation sessions (software crashing midway through the testing session), leaving a total of 116 participants.

Stimuli

Color, full-body photographs of Caucasian and Asian individuals were obtained from a database built for a larger study. Photographs were taken with participants wearing standard gray, tight-fitting shorts, and singlet, standing in a Munsell N5 gray-painted photo booth, under standardized lighting and with all camera settings held constant (Sturman et al., 2017).

Twenty-two Asian and 22 Caucasian identities were used in this study. Height and weight measurements were taken and BMI (Asian M = 22.19, SD = 3.14; Caucasian M = 22.18, SD = 3.22) calculated, which were then used to match each Asian identity to a corresponding Caucasian identity. Images were resized to 450 × 900 pixels, and all identifying markings or tattoos were digitally removed using the clone stamp tool in Adobe Photoshop CS6. All identities used were within one SD of the mean BMI in the larger database. For each identity, the body (from the neck downward) was expanded horizontally by 50% and contracted by 50%, using the Spherize tool in Photoshop (which has previously been shown to produce stimuli that successfully induce body size adaptation effects; Brooks et al., 2016). This created two images of the same identity that appeared to differ drastically in body fat. These were used as the adaptation stimuli (**Figure 1**).

Further 12 images, horizontally expanded or contracted in 5% increments, up to and including ±30%, were created as the test stimuli to add to the original “0%” image (**Figure 2**). The faces of each identity remained visible so that race could easily be discerned, but faces were left unaltered by the Spherize manipulation to avoid the possibility of confounding effects of face adaptation.

Procedure

Participants were pseudorandomly assigned to one of four adaptation conditions to determine the adaptation stimuli with which they would be presented – Expanded Asian (A+), Expanded Caucasian (C+), Contracted Asian (A−), or Contracted Caucasian (C−). Participants provided their age, race, and sex *via* a demographics questionnaire in Qualtrics, before proceeding to the practice phase. The practice phase consisted of a series of two Asian and two Caucasian test identities (each Asian test identity matched for initial BMI with a Caucasian test identity), presented once each, one at a time in random order. A method of adjustment task programmed in Matlab R2017b with Psychtoolbox 3 was used. For each test identity, moving the mouse horizontally cycled through the 13 frames of the test identity’s transformation. Participants were instructed that moving the mouse horizontally would change the appearance of the body (but were not told it was a width manipulation) and were asked to “make the body look as normal as possible”, then click to save the data, and move onto the next identity. The initial frame presented was randomized. Each trial was preceded by a beep to indicate that a response was required.

Next, in the baseline test phase, participants were presented with a series of 20 test identities (10 Asian and 10 Caucasian, each Asian identity matched for initial BMI with a Caucasian identity), selected at random from the pool, once each, one at a time in random order, and asked to make them appear as normal as possible.

In the adaptation test phase, participants were presented with a 2-min slide show of 10 identities according to their condition (expanded or contracted Asian or Caucasian bodies).

FIGURE 1 | Examples of Asian (top) and Caucasian (bottom), contracted (left) and expanded (right) adaptation stimuli, matched on initial BMI. All faces were visible during experimentation.

Each identity was presented six times, for a total duration of 12 s. Participants were not required to make a response, and no beep sound was played. Following this initial adaptation, participants were presented with the same 20 test identities from the baseline phase (10 Asian and 10 Caucasian, matched on initial BMI), once each, one at a time, in random order, and asked to make the bodies as normal as possible. Between each trial, a series of six "top up" adaptation stimuli were selected at random from the adaptation identities and presented for 1 s each (a total of 6 s) to ensure the maintenance of the adaptation effect (Brooks et al., 2016). Participants were asked to simply observe the top up stimuli without making a response.

FIGURE 2 | Original (center) and contracted (left) and expanded (right) endpoints of the manipulation used to produce the test stimuli. All faces were visible during experimentation.

Data Processing and Analysis

Baseline point of subjective normality (PSN) was calculated for each participant as the average amount of expansion/contraction chosen to make the bodies look as normal as possible across the baseline trials. Adapted PSN was calculated for each participant as the average amount of expansion/contraction chosen across the adaptation test phase trials. Change in PSN (ΔPSN) was calculated by subtracting baseline PSN from adapted PSN, such that a positive (negative) value indicated that the participant's perception of normal body size had become wider (narrower) as a result of adaptation. This was used as the main dependent variable.

Separate one-sample *t*-tests were used to test for the presence of aftereffects in each of the four conditions for each of the test races. A 2 (race of test stimuli; within subjects) × 2 (race of adaptation stimuli; between subjects) × 2 (race of participant; between subjects) × 2 (direction of adaptation; expanded or contracted; between subjects) mixed ANOVA was used to determine whether there was significant transfer of adaptation across bodies of different races, for participants of different races.

Results

The average ΔPSN for each condition was found to be significantly different from 0 in the predicted direction (**Figure 3**; those exposed to expanded/contracted adaptation stimuli showed positive/negative ΔPSN scores) across all eight one-sample *t*-tests (all $p < 0.001$), suggesting that aftereffects were successfully induced in the predicted direction in all eight conditions.

In the ANOVA, as predicted, a significant main effect of direction of adaptation was significant, $F(1,108) = 177.72$, $p < 0.001$, $\eta_p^2 = 0.62$, with those exposed to expanded adaptation conditions showing positive ΔPSN scores ($M = 2.59$, SD = 1.83) and those in the contracted adaptation conditions showing negative ΔPSN scores ($M = -1.33$, SD = 1.42). Unexpectedly however, there was a significant interaction between direction of adaptation and race of participant, $F(1,108) = 14.60$, $p < 0.001$, $\eta_p^2 = 0.12$. Caucasian participants appeared to be experiencing stronger average body size aftereffects compared to the Asian participants in both expanded, $t(49.44) = -3.19$, $p = 0.002$, $d = 0.91$ (Caucasian $M = 3.27$, SD = 2.01; Asian $M = 1.84$, SD = 1.26), and contracted, $t(57) = 2.16$, $p = 0.035$, $d = 0.57$ (Caucasian $M = -1.71$, SD = 1.33; Asian $M = -0.93$, SD = 1.42) adaptation conditions. No other significant main effects or interactions were found (all *p*'s > 0.05).

Importantly, there was no significant interaction found between race of test stimuli and race of adaptation stimuli, $F(1,108) = 1.67$, $p = 0.199$, $\eta_p^2 = 0.02$, suggesting that transfer of aftereffects was complete across stimulus races. The lack of a significant result in a standard null-hypothesis significance test (NHST) should not, however, be taken as evidence of no difference between groups (absence of evidence is not evidence of absence). This result was therefore followed up with equivalence testing. This technique reverses the typical assumptions of NHST, setting the null hypothesis to "there is a difference between the means," and the alternative hypothesis to "the means are equivalent" (Lakens, 2017). The two one-sided tests (TOST) equivalence testing method was used to determine if the aftereffects were significantly equivalent in conditions where the race of the test stimuli was congruent vs. conditions where the race of the test stimuli was incongruent with the race of the adaptation stimuli. Upper and lower bounds were set to $d_z = \pm 0.35$

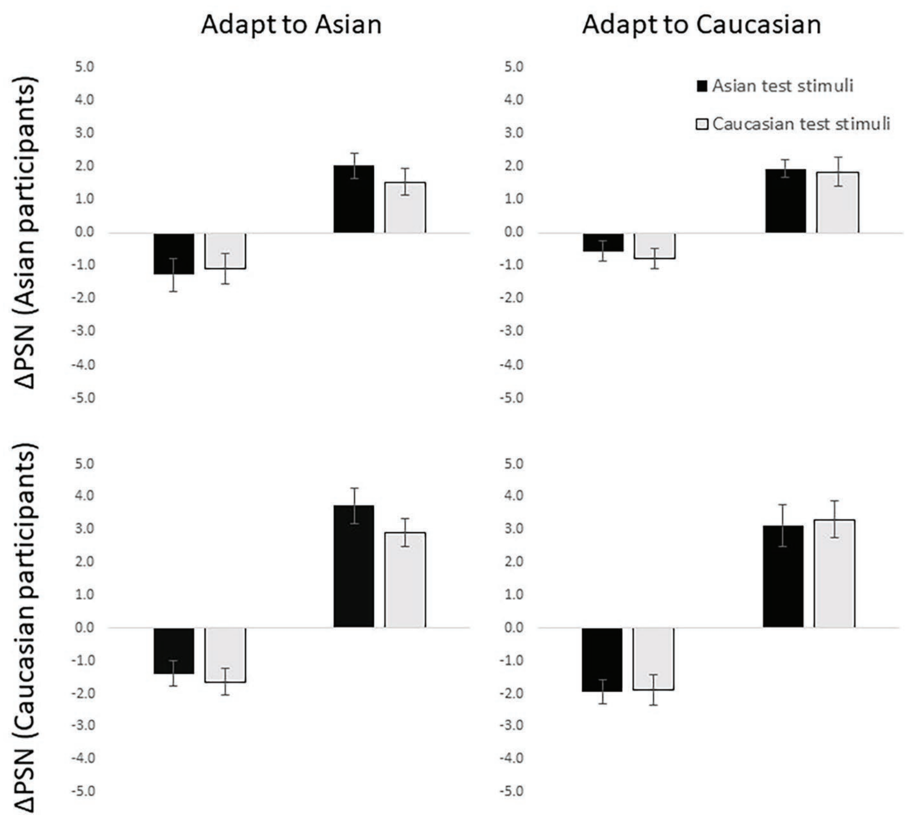

FIGURE 3 | ΔPSN scores for Asian (top) and Caucasian (bottom) participants adjusting Asian (black bars) and Caucasian (light bars) test identities following exposure to Asian (left) and Caucasian (right) adaptation stimuli. Error bars show standard error of the mean.

(equivalent to a ±2.5% spherize transform – half of the difference between two adjacent frames in the transform sequence) (Lakens, 2017). The TOST procedure indicated that the observed effect size ($d_z = -0.12$) was significantly within the equivalent bounds, $t(115) = 2.65$, $p = 0.030$.

Discussion

Experiment 1 found significant body size adaptation in the predicted directions in all conditions, such that exposure to expanded bodies resulted in an aftereffect of body size underestimation (i.e., more expanded bodies being perceived as normal), while exposure to contracted bodies resulted in body size overestimation (i.e., more contracted bodies being perceived as normal). The magnitude of the aftereffect was significantly equivalent in congruent and incongruent race conditions, suggesting that the transfer of adaptation across races of bodies was complete. Finally, Asian participants appeared to experience a significantly weaker body size adaptation effect compared to Caucasian participants, regardless of the race of the test and adaptation stimuli.

Experiment 2

Experiment 2 used a contingent adaptation paradigm, in which participants completed a method of adjustment task to determine the body size that they perceived as most "normal" (point of subjective normality; PSN) before and after exposure to adaptation bodies, which were either expanded Asians and contracted Caucasians or contracted Asians and expanded Caucasians. Following the results of Experiment 1, we predicted that there would be complete transfer of body size aftereffects across races of bodies, with a canceling effect leading to much reduced or even absent aftereffects in both races of stimuli.

Methods

Participants

Forty-five female participants were recruited in Sydney, Australia and Kota Kinabalu, Malaysia. Twenty-four Australian Caucasian participants ($M_{age} = 19.5$, SD = 2.25) were recruited in Sydney, Australia and 21 East/Southeast Asian Malaysian participants ($M_{age} = 24.4$, SD = 2.25) were recruited in Kota Kinabalu, Malaysia in the same way as Experiment 1, giving 95% power to detect a small-medium effect size for the hypothesized test race × participant race × adaptation condition interaction in the planned ANOVA (calculated using G*Power v3.1.9.2). Two Caucasian participants were excluded from the final analysis because they responded identically to every test stimulus.

Stimuli

The stimuli were the same as for Experiment 1.

Procedure

Experiment 2 employed a 2 (test race; within-subjects) × 2 (adaptation condition; between subjects) × 2 (participant race; between subjects) mixed factorial design. Participants were pseudorandomly assigned to one of two conditions, one in which participants were exposed to five expanded Asian and five contracted Caucasian adaptation stimuli, matched for initial BMI (A+/C−) and the other in which participants were exposed to five contracted Asian and five expanded Caucasian adaptation stimuli, matched for initial BMI (A−/C+), six times each for a total of 2 min. Top up stimuli in the adapted test phase (three Asian and their initial BMI-matched Caucasian counterparts) were drawn at random from these adaptation stimuli each trial. All other aspects of the procedure were the same as Experiment 1.

Data Processing and Analysis

ΔPSN was calculated as in Experiment 1. Separate one-sample *t*-tests, for participants of each race, in each adaptation condition, and for test bodies of each race, were conducted comparing ΔPSN values against a reference value of 0 to determine whether PSNs changed from baseline to adapted test phase. A 2 (adaptation condition) × 2 (race of test body) × 2 (participant race) mixed ANOVA was used to examine the effects of race on the magnitude and direction of the aftereffect.

For conditions in which the adaptation and test stimuli were incongruent, scores were multiplied by −1, such that a positive result indicated an adaptation effect in the direction predicted if race-contingent adaptation was to occur. TOST was used to test for equivalence of effects between all congruent and incongruent conditions.

Results

No significant change in PSN was found for participants of either race, in either adaptation condition, for test bodies of either race (all p's > 0.05).

In the ANOVA, no significant main effects or interactions were found (all p's > 0.05), indicating that significant contingent aftereffects were not detected. The TOST procedure indicated that the observed effect size (d_z = −0.06) was significantly within the equivalent bounds of d_z = ±0.35 (±4% of spherize transform – less than the difference between two adjacent frames in the transform sequence), $t(42) = 1.90$, $p = 0.032$, suggesting that aftereffects were of equivalent size in congruent and incongruent conditions.

Discussion

Participants did not show any significant change in their perception of normal body size after adaptation to stimuli of different races whose size had been manipulated in opposite directions. This result has a number of possible interpretations. Firstly, it is possible that no meaningful visual adaptation took place. However, given that this experiment was modeled on a previous investigation that showed significant contingent adaptation under highly similar conditions (Brooks et al., 2016) and given the significant adaptation effects detected in Experiment 1, this seems unlikely. An alternative explanation is that the neural populations processing body size for Asian and Caucasian bodies are largely or completely overlapping. In this case, the transfer of body size adaptation across races is predicted to be large or complete, as revealed by the significant equivalence test, such that the adaptation to the expanded and contracted bodies cancel each other out, to result in no net effect. This interpretation is consistent with the finding of no reduction in visual body size aftereffects for race-incongruent conditions in Experiment 1.

GENERAL DISCUSSION

Across both experiments, participants showed equivalence in their adaptation to bodies of different races. In Experiment 1, when exposed to only expanded or contracted versions of only one race during the adaptation phase, participants exhibited body size adaptation effects in the same direction and of equivalent magnitude in test stimuli of both races. It was noted, however, that Asian participants exhibited body size adaptation effects of reduced magnitude compared to Caucasian participants. In Experiment 2, participants showed no overall body size aftereffects when exposed to expanded Asian and contracted Caucasian adaptation bodies (or vice versa) in the same session, and aftereffects were equivalent for congruent and incongruent pairings of race of adaptation stimuli and race of test stimuli implying that, rather than resulting in simultaneous adaptation in opposite directions in different races, this exposure led to a cancellation effect.

A number of studies have demonstrated contingent adaptation for different race faces (Jaquet et al., 2008; Gwinn and Brooks, 2013; Gwinn and Brooks, 2015a,b) and partial transfer of visual adaptation across faces of those same races (Jaquet et al., 2008), with authors inferring that the processing of faces of different races takes place in partially dissociated neural populations. Similarly, partial transfer of body size aftereffects has been demonstrated across bodies of different identities (own- vs. other-identity bodies), suggesting partial dissociation of the neural populations encoding body width in one's own vs. other individuals' bodies (Brooks et al., 2016). Similar results have been shown for different gendered bodies (Brooks et al., 2019). However, our results suggest that body size aftereffects show complete transfer across bodies of different races, suggesting that a single, race-general neural population encodes the width of bodies of different races.

Contingent adaptation is dependent upon the classification of target stimuli into different groups (Little et al., 2008). The lack of race-contingent body size adaptation effects in the current studies may therefore reflect a lack of automatic categorization of bodies by race. This lack of racial categorization based on bodies is also reflected in studies examining the other-race effect (the well-known phenomenon in which it is more difficult to recognize individuals of a different race than individuals of one's own race). While the other-race effect is well established in faces (Hayden et al., 2007), similar effects can be induced in own-race faces by the induction of outgroup classification of faces, suggesting that outgroup classification may be necessary to induce the other-race effect (Zheng and Segalowitz, 2014). The other-race effect appears to be absent in bodies, however, providing further support for the suggestion that racial classification may not be automatic in bodies (Humphreys et al., 2005).

Unexpectedly, we found that Malaysian participants exhibited reduced body size adaptation effects compared to Australian participants across test and adaptation stimuli of both races. Further research is required to explain this phenomenon. However, we note that this novel finding fits with a broader pattern of differences between Caucasian and Asian participants in their performance on visual cognition tasks, including differences in the processing of faces (Blais et al., 2008), which some authors have attributed to broader cultural differences in cognitive styles (Blais et al., 2008). Our results suggest that racial/cultural differences in visual processing result in reduced susceptibility to visual adaptation among Asian populations. Although it is impossible to distinguish the environmental from the biological origins of these perceptual differences, it may be productive to investigate cultural differences in cognitive styles as an explanation for the origins of this difference in susceptibility to body size adaptation effects. One possible mechanism by which this may operate is that Asian participants may have directed more of their visual attention to the faces, and less to the bodies, than Caucasian participants, perhaps due to stronger cultural taboos against looking at bodies. However, it should be noted that Australia and Malaysia also differ in their degree of economic development, with Australia having an estimated GDP per capita of US$50,400 (CIA, 2018), compared to Malaysia's $29,100 (CIA, 2017), and economic development has been previously linked to BMI preferences (Furnham et al., 2007), possibly *via* increased exposure to media representations of thin idealized bodies as economic development increases (Boothroyd et al., 2016).

The body size aftereffect has been demonstrated to manipulate body misperception and dissatisfaction in quite negative ways across Western populations. Due to the pervasion of thin media images in modern Western, and increasingly Asian, society, understanding why individuals in certain cultures are less susceptible to this effect may have implications for interventions designed to reduce the harm associated with BSSM.

In conclusion, our results do not support the suggestion that the reduced body dissatisfaction seen in some non-Caucasian groups (DeBraganza and Hausenblas, 2010) can be explained by partial transfer of body size aftereffects from thin-idealized Caucasian bodies in the media to their own bodies. However, the unexpected demonstration of smaller body size aftereffects for Asian participants in general offers promise in providing a potential explanation for the reduced levels of body dissatisfaction shown in these cultures.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this manuscript will be made available by the authors, to any qualified researcher.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Macquarie University Human Research Ethics Committee and the Medical Ethics Committee of the Universiti Malaysia Sabah. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LG-F and IS helped in conception, design, collection, analysis, and interpretation of data and contributed in drafting the article. CT Collected data and helped in revision of the article. KB helped in conception, design, interpretation of data, and revision of article. JM contributed in design, interpretation of data, and revision of the article. RS helped in interpretation of data and revision of the article.

REFERENCES

Blais, C., Jack, R. E., Scheepers, C., Fiset, D., and Caldara, R. (2008). Culture shapes how we look at faces. *PLoS One* 3:e3022. doi: 10.1371/journal.pone.0003022

Boothroyd, L. G., Jucker, J. L., Thornborrow, T., Jamieson, M. A., Burt, D. M., Barton, R. A., et al. (2016). Television exposure predicts body size ideals in rural Nicaragua. *Br. J. Psychol.* 107, 752–767. doi: 10.1111/bjop.12184

Boothroyd, L. G., Tovée, M. J., and Pollet, T. V. (2012). Visual diet versus associative learning as mechanisms of change in body size preferences. *PLoS One* 7:e48691. doi: 10.1371/journal.pone.0048691

Bould, H., Carnegie, R., Allward, H., Bacon, E., Sapseid, M., Button, K., et al. (2018). Effects of visual adaptation on perception of and satisfaction with own body size: two randomised studies. *R. Soc. Open Sci.* 5:171387. doi: 10.1016/S0924-977X(16)70056-3

Brooks, K. R., Baldry, E., Mond, J., Stevenson, R. J., Mitchison, D., and Stephen, I. D. (2019). Gender and the body size aftereffect: Implications for neural processing. *Front. Neurosci.* 13:1100. doi: 10.3389/fnins.2019.01100

Brooks, K. R., Mond, J. M., Stevenson, R. J., and Stephen, I. D. (2016). Body image distortion and exposure to extreme body types: contingent adaptation and cross adaptation for self and other. *Front. Neurosci.* 10:334. doi: 10.3389/fnins.2016.00334

Challinor, K. L., Mond, J., Stephen, I. D., Mitchison, D., Stevenson, R. J., Hay, P., et al. (2017). Body size & shape misperception and visual adaptation: an overview of an emerging research paradigm. *J. Int. Med. Res.* 45, 2001–2008. doi: 10.1177/0300060517726440

CIA (2017). Malaysia. World Factb. Available at: https://www.cia.gov/library/publications/the-world-factbook/geos/my.html (Accessed November 27, 2018).

CIA (2018). Australia. CIA World Factb. Available at: https://www.cia.gov/library/publications/the-world-factbook/geos/as.html (Accessed January 24, 2018).

DeBraganza, N., and Hausenblas, H. A. (2010). Media exposure of the on ideal physique women's body dissatisfaction and mood. *J. Black Stud.* 40, 700–716. doi: 10.1177/0021934708317723

Furnham, A., Swami, V., Tovee, M. J., Furnham, A., and Swami, V. (2007). "Healthy body equals beautiful body? Changing perceptions of health and attractiveness with shifting socioeconomic status" in *The body beautiful*. eds. V. Swami and A. Furnham (London: Palgrave Macmillan), 108–128.

Griffiths, S., Hay, P., Mitchison, D., Mond, J. M., McLean, S. A., Rodgers, B., et al. (2016). Sex differences in the relationships between body dissatisfaction, quality of life and psychological distress. *Aust. N. Z. J. Public Health* 40, 508–522. doi: 10.1111/1753-6405.12538

Groesz, L. M., Levine, M. P., and Murnen, S. K. (2002). The effect of experimental presentation of thin media images on body satisfaction: a meta-analytic review. *Int. J. Eat. Disord.* 31, 1–16. doi: 10.1002/eat.10005

Gwinn, O. S., and Brooks, K. R. (2013). Race-contingent face aftereffects: a result of perceived racial typicality, not categorization. *J. Vis.* 13, 1–11. doi: 10.1167/13.11.13

Gwinn, O. S., and Brooks, K. R. (2015a). Face encoding is not categorical: consistent evidence across multiple types of contingent aftereffects. *Vis. Cogn.* 6285, 1–27. doi: 10.1080/13506285.2015.1091800

Gwinn, O. S., and Brooks, K. R. (2015b). No role for lightness in the encoding of Black and White: Race-contingent face aftereffects depend on facial morphology, not facial luminance. *Vis. Cogn.* 23, 597–611. doi: 10.1080/13506285.2015.1061085

Hayden, A., Bhatt, R. S., Joseph, J. E., and Tanaka, J. W. (2007). The other-race effect in infancy: evidence using a morphing technique. *Infancy* 12, 95–104. doi: 10.1080/15250000701298923

Humphreys, G. W., Hodsoll, J., and Campbell, C. (2005). Attending but not seeing: the "other race" effect in face and person perception studied through change blindness. *Vis. Cogn.* 12, 249–262. doi: 10.1080/13506280444000148

Jaquet, E., Rhodes, G., and Hayward, W. G. (2008). Race-contingent aftereffects suggest distinct perceptual norms for different race faces. *Vis. Cogn.* 16, 734–753. doi: 10.1080/13506280701350647

Jucker, J. L., Thornborrow, T., Beierholm, U., Burt, D. M., Barton, R. A., Evans, E. H., et al. (2017). Nutritional status and the influence of TV consumption on female body size ideals in populations recently exposed to the media. *Sci. Rep.* 7, 1–9. doi: 10.1038/s41598-017-08653-z

Khor, G. L., Zalilah, M. S., Phan, Y. Y., Ang, M., Maznah, B., and Norimah, A. K. (2009). Perceptions of body image among Malaysian male and female adolescents perceptions of body image among Malaysian male and female adolescents. *Singap. Med. J.* 50, 303–311. http://europepmc.org/abstract/MED/19352576

Lakens, D. (2017). Equivalence tests: a practical primer for t tests, correlations, and meta-analyses. *Soc. Psychol. Personal. Sci.* 8, 355–362. doi: 10.1177/1948550617697177

Little, A. C., DeBruine, L. M., Jones, B. C., and Waitt, C. (2008). Category contingent aftereffects for faces of different races, ages and species. *Cognition* 106, 1537–1547. doi: 10.1016/j.cognition.2007.06.008

Mohr, H. M., Rickmeyer, C., Hummel, D., Ernst, M., and Grabhorn, R. (2016). Altered visual adaptation to body shape in eating disorders: implications for body image distortion. *Perception* 45, 725–738. doi: 10.1177/0301006616633385

Powell, T. M., de Lemos, J. A., Banks, K., Ayers, C. R., Rohatgi, A. A., Khera, A., et al. (2010). Body size misperception: a novel determinent in the obesity epidemic. *Arch. Intern. Med.* 170, 1695–1697. doi: 10.1001/archinternmed.2010.314

Quick, V., Nansel, T. R., Liu, D., Lipsky, L. M., Due, P., and Iannotti, R. J. (2015). Body size perception and weight control in youth: 9-year international trends from 24 countries. *Int. J. Obes.* 38, 988–994. doi: 10.1038/ijo.2014.62. Body

Rhodes, G., Jeffery, L., Evangelista, E., Ewing, L., Peters, M., and Taylor, L. (2011). Enhanced attention amplifies face adaptation. *Vis. Res.* 51, 1811–1819. doi: 10.1016/j.visres.2011.06.008

Robinson, E., and Kirkham, T. C. (2014). Is he a healthy weight? Exposure to obesity changes perception of the weight status of others. *Int. J. Obes.* 38, 663–667. doi: 10.1038/ijo.2013.154

Schooler, D., Ward, L. M., Merriwether, A., and Caruthers, A. (2004). Who's that girl: television's role in the body image development of young white and black women. *Psychology* 28, 38–47. doi: 10.1111/j.1471-6402.2004.00121.x

Stephen, I. D., and Perera, A. T.-M. (2014). Judging the difference between attractiveness and health: does exposure to model images influence the judgments made by men and women? *PLoS One* 9:e86302. doi: 10.1371/journal.pone.0086302

Sturman, D., Stephen, I. D., Mond, J., Stevenson, R. J. R. J., and Brooks, K. R. (2017). Independent aftereffects of fat and muscle: implications for neural encoding, body space representation, and body image disturbance. *Nat. Sci. Rep.* 7:40392. doi: 10.1038/srep40392

Thompson, P., and Burr, D. (2009). Visual aftereffects. *Curr. Biol.* 19, 11–14. doi: 10.1016/j.cub.2008.10.014

Wardle, J., Haase, A. M., and Steptoe, A. (2006). Body image and weight control in young adults: international comparisons in university students from 22 countries. *Int. J. Obes.* 30, 644–651. doi: 10.1038/sj.ijo.0803050

Yaemsiri, S., Slining, M. M., and Agarwal, S. K. (2011). Perceived weight status, overweight diagnosis, and weight control among US adults: the NHANES 2003–2008 study. *Int. J. Obes.* 35, 1063–1070. doi: 10.1038/ijo.2010.229

Yang, H., Shen, J., Chen, J., and Fang, F. (2011). Face adaptation improves gender discrimination. *Vis. Res.* 51, 105–110. doi: 10.1016/j.visres.2010.10.006

Zheng, X., and Segalowitz, S. J. (2014). Putting a face in its place: in- and out-group membership alters the N170 response. *Soc. Cogn. Affect. Neurosci.* 9, 961–968. doi: 10.1093/scan/nst069

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Body Size Adaptation Alters Perception of Test Stimuli, Not Internal Body Image

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Recent studies have reported that adaptation to extreme body types produces aftereffects on judgments of body normality and attractiveness, and also judgments of the size and shape of the viewer's own body. This latter effect suggests that adaptation could constitute an experimental model of media influences on body image. Alternatively, adaptation could affect perception of test stimuli, which should produce the same aftereffects for judgments about participant's own body or someone else's body. Here, we investigated whether adaptation similarly affects judgments about one's body and other bodies. We were interested in participants' own body image judgments, i.e., we wanted to measure the mental representations to which the test stimuli were compared and not the perception of test stimuli *per se*. Participants were adapted to pictures of thin or fat bodies and then rated whether bodies were fatter or thinner than either: their own body, an average body (Experiment 1), or the body of another person (Experiments 2 and 3). By keeping the visual stimuli constant but changing the task/type of judgment, i.e., the internal criterion participants are asked to judge the bodies against, we investigated how adaptation affects different stored representations of bodies, specifically own body image vs. representations of others. After adaptation, a classic aftereffect was found, with judgments biased away from the adapting stimulus. Critically, aftereffects were nearly identical for judgments of one's own body and for other people's bodies. These results suggest that adaptation affects body representations in a generic way and may not be specific to the own body image.

Keywords: body representations, visual perception, sensory adaptation, self, aftereffects

INTRODUCTION

In our daily lives, we constantly experience our own bodies directly through touch and proprioception, but most of our visual experience with bodies comes from seeing other people. For most of us, other people's bodies are a ubiquitous part of our "visual diet" (Boothroyd et al., 2012). Moreover, through the media, we are bombarded with images of other, often idealized, bodies. Previous research showed that exposure to thin, idealized images changes attitudes toward one's own body, increases body dissatisfaction, and negatively affects mood

(Groesz et al., 2002; Tiggemann and McGill, 2004). Clearly, media can shape our beliefs and attitudes, but can exposure to certain body types change the way we actually *perceive* our own bodies? Recently, several studies suggested that this might be the case and proposed visual adaptation, i.e., a shift in perceptual judgment after prolonged exposure to a certain stimulus, as one of the mechanisms that may be involved in this process (Hummel et al., 2012b; Brooks et al., 2016; Bould et al., 2018; Stephen et al., 2018). According to this emerging theory, exposure to idealized, often extremely thin bodies (e.g., "size zero" models) causes our own body to be perceived as fatter than it really is. Alternatively, adaptation to extreme body types might affect the way people visually perceive test stimuli, without affecting the viewer's own body image at all. Here, we further investigated whether short-term effects of adaptation could constitute an experimental model for the long-term effects of media influences on body image, by asking whether perceptual changes induced by body size adaptation show specificity to one's own body or, on the contrary, are similar across visual representations of bodies in general. We were interested in body image judgments, i.e., we wanted to measure the mental representations to which the test stimuli were compared.

Body representations arise from many different sources: interoceptive signals from internal organs; sensory input from the external world coming from modalities such as touch and vision; and also from abstract knowledge, beliefs, and attitudes (see Longo et al., 2010 for a review). The body image is a complex concept that involves both sensory and cognitive components. While many body representations are thought to be largely based on somatosensory signals about touch, proprioception, pain, etc. (Longo, 2015), the body image is thought to be predominantly visual. Indeed, in his classic definition, Schilder (1935/1950) used overtly visual language in describing the body image as "the picture of our own body which we form in our mind, that is to say the way in which the body appears to ourselves" (p. 11). Although, in the literature, body image is often used in reference to attitudes and feeling about one's body, here we wanted to specifically focus on its visual component, i.e., the way the body appears to us in the mind's eye. As a predominantly visual representation, is the body image then shaped by visual exposure to other bodies?

Visual adaptation produces aftereffects which bias perception in the direction opposite to the adapting stimulus. For example, in the classic waterfall illusion, after a short exposure to the flowing water of a waterfall, when the observer looks at a static image, e.g., the space beside the waterfall, she will perceive it as moving upward (Barlow and Hill, 1963; Anstis et al., 1998). Visual adaptation aftereffects are widely studied and well established for basic features, such as motion (Wohlgemuth, 1911), orientation (Gibson and Radner, 1937), and color (McCollough, 1965), which are thought to be processed mainly at lower levels of visual hierarchy. However, research on adaptation to complex stimuli such as faces and bodies suggests that adaptation is not limited to basic features and may operate at higher levels of processing (Rhodes et al., 2003; Webster et al., 2004; Fox and Barton, 2007; Pond et al., 2013; Brooks et al., 2018). Research on face adaptation shows that adaptation to faces with consistent distortions, i.e., compressing or expanding the center of a face, causes normal faces to appear distorted in the opposite direction (Rhodes et al., 2003). In a similar way, gender-ambiguous faces are judged as more masculine after prolonged viewing of female faces, whereas adaptation to male faces induces the opposite effect (Webster et al., 2004; Pond et al., 2013). Facial emotional expressions also produce similar aftereffects: after exposure to happy faces, observers tend to perceive subsequent neutral expressions as sad (Fox and Barton, 2007).

Research on body adaptation has shown that brief exposure to unfamiliar thin bodies significantly alters people's perception of body attractiveness, normality, and ideals, in the direction of the thin adaptor (Winkler and Rhodes, 2005; Glauert et al., 2009). Moreover, adaptation to participants' own bodies, depicting them as either thinner or fatter, can also alter the way participants judge images of their own bodies. After adaptation to the thin version of their own body, participants rated a thinner than actual image to be the most accurate depiction of their own body and vice versa for the fat adaptor (Hummel et al., 2012a,b, 2013). Interestingly, the effect of body adaptation transfers across identities, with comparable effects for unfamiliar and own body adaptors (Hummel et al., 2012b; Brooks et al., 2016). Moreover, it is specific to bodies, and does not transfer between bodies and narrow/wide rectangles Hummel et al. (2012a). Taken together, these findings show that exposure to thin images not only affects perceived norms and ideals (Winkler and Rhodes, 2005; Glauert et al., 2009) but can also change how participants judge images of their own body – causing the actual image of the participant's body to appear fatter (Hummel et al., 2012b; Brooks et al., 2016). These results suggest that visual adaptation may serve as an experimental model of the effect that exposure to thin bodies presented in media has on body image. Following this line of reasoning, Challinor et al. (2017) proposed that including visual adaptation as a part of treatment may have therapeutic effect on patients with body image distortions in conditions such as anorexia nervosa.

Here, we investigated whether adaptation affects visual body image in a self-specific way. There is clear evidence that body size adaptation changes perception of bodies as indicated by the shift in perceived norms as the result of aftereffects. The question nevertheless remains how similar the magnitude of the aftereffects is for one's own body (i.e., the body image) and for bodies in general. Specifically, it is not known whether exposure to bodies affects judgments about our own body in a self-specific way, or the effect is generic to all bodies. For visual adaptation to constitute an experimental model of media effect on body image distortions, some overlap in the way adaptation affects one's own body and bodies of others is required to allow the transfer of aftereffects from media images to body image as it has been argued previously (Brooks et al., 2016). However, the effect that adaptation has on one's own body should also differ from the general effect of adaptation on all images of bodies. If adaptation affects all bodies equally, the relative difference between one's own body and other bodies should not change. In other words, both our own bodies and bodies presented in media should be affected by adaptation. In consequence, our own body should not appear to us as fatter in the whole continuum of bodies, i.e., if we were to compare our body to other bodies. Interestingly, there are many clinical conditions in which people have distorted image of their own body, but not other people's (whereas the opposite is rare). Studies have reached divergent conclusions about whether patients with eating disorders selectively overestimate the size of their own bodies (e.g., Mizes, 1992; Øverås et al., 2014) or overestimate bodies in general (e.g., Tovée et al., 2000; Horndasch et al., 2015). In a study by Guardia et al. (2012), patients showed biased judgments about their own actions but could accurately judge the affordances of others. These results suggest that anorexia nervosa patients do not have distorted representations of other people's bodies.

To investigate whether visual exposure to extreme body types affects the perception of our own body and of other bodies in similar or different ways, we designed three experiments in which female participants judged the same test images but compared them to different internal representations. After adaptation to pictures of either extremely thin or extremely fat bodies, participants were asked to rate whether subsequently presented bodies were fatter or thinner than either: their own body (all three experiments), an average body (Experiment 1), or a body of a specific other person (Experiments 2 and 3). By keeping the visual stimuli constant but changing the internal criterion (or anchor point) that participants are asked to judge the bodies against, we investigated how adaptation affects different stored representations of bodies, specifically, and not the perception of the test stimuli *per se*. Note that in a body image judgment, the reference (a photograph, a silhouette, or even a piece of string) is usually compared to one's mental representation of one's own body, regardless of the nature of the reference itself (e.g., Slade and Russell, 1973; Garner et al., 1976; Thompson et al., 1986; Schneider et al., 2009). Interestingly, a previous study by de la Rosa et al. (2014) reported modulation of action adaptation aftereffects across two conditions that had identical adapting and test stimuli but differed with respect to the information that was provided prior to the adaptation, i.e., the social context, suggesting that the context of the task can affect adaptation aftereffects.

EXPERIMENT 1

In Experiment 1, we investigated the effect of visual adaptation to thin bodies on judgments about one's own body and about an average body. If adaptation has a specific effect on body image, the magnitude of adaptation aftereffects should differ depending on whether participants are comparing the test image to their own body or somebody else's. If, in contrast, adaptation affects body image judgments by altering perception of the test stimuli, identical aftereffects should be found in both cases.

Methods

Participants

Due to the nature of our stimuli (depicting female bodies), we restricted our sample to female participants. A different group of participants was selected in each study. Twenty participants (mean age: 28.1, SD: 11.6, range: 18–65; mean body mass index, BMI: 21.9, SD: 3.1, range 17.9–29.1) took part in Experiment 1. All participants had normal or corrected to normal vision. All participants gave informed consent and were paid for their participation. The procedures were approved by the ethics board of the Department of Psychological Sciences, Birkbeck, University of London.

Previous studies showed that adaptation to bodies produces strong and robust effects. For example, Hummel et al. (2012b) using similar type of stimuli and similar type of judgments in two experiments obtained Cohen's d_z's of 2.87 and 1.04. We conducted a power analysis using G*Power 3.1 taking the smaller of these two effect sizes, an alpha value of 0.05 and power of 0.95, which indicated that 12 participants were required. In addition, piloting data using our paradigm showed adaptation effects in virtually every participant. Thus, we believe that our sample size of 20 participants makes this experiment well powered to address this issue.

Stimuli

We used a set of 89 images of female bodies rendered from 3D avatars generated in DAZ Studio 4.8 (DAZ Productions, http://www.daz3d.com/). Avatars' BMI ranged from 13 (emaciated) to 35 (obese) with an increment of 0.25 BMI units between each stimulus (with a total of 89 images; see **Figure 1** for examples). To approximate the avatars' BMI, we used Cornelissen et al.'s (2009) formula to calculate the waist-to-hip ratio (WHR) for white UK women of reproductive age: WHR = (2.057 × BMI + 29.67)/(1.842 × BMI + 56.004), which is based on data from Health Survey for England (2003). Following this formula, waist and hip circumferences were estimated for each required BMI from the range of 13–35. Avatars' waist and hip circumferences were adjusted using the Universal Sizing Apparatus tool (Rocketship Technologies Inc., http://rocketship3d.com/). The height of the avatars was kept constant at 170 cm. The avatars were rotated approximately 45° around the vertical axis (in the transverse plane) to obtain a viewing angle that would provide more information about the body dimensions compared to the straight-facing view. A recent study by Cornelissen et al. (2018) confirmed that this three-quarter view results in the most accurate estimations of body size. Finally, 2D images were rendered from the avatars, as shown in **Figure 1**.

Procedures

Each experiment consisted of the *Baseline* and the *Adaptation* phase conducted on the same day with a short break (1–2 min). In Experiments 1 and 2, a very thin body (BMI = 13) was used as an adapting stimulus. In Experiment 3, the procedure was repeated twice, using both a very thin (BMI = 13) and a very fat adaptor (BMI = 35). In all experiments, participants

FIGURE 1 | Stimuli used in the experiments. A continuum of 89 body shapes was created, ranging from extremely thin (i.e., BMI = 13) to obese (i.e., BMI = 35). 3D modeling software was used to model these changes in a biologically realistic way. The numbers indicate the estimated body mass index (BMI) of the avatars.

sat approximately 50 cm from the screen with head movements unrestricted. Images were presented in the center of a 24-inch screen (resolution: 1,600 × 1,200 pixels; refresh rate: 75 Hz), on a black background. The height of each image was 18 cm (20° visual angle). Stimuli were presented using Psychtoolbox (Brainard, 1997), running on MATLAB (Mathworks, Natick, MA, USA). The PSEs were calculated using a Bayesian adaptive algorithm QUEST (Watson and Pelli, 1983). Statistical analyses were performed in JASP (JASP Team, 2017).

In the Baseline phase, each trial began with a blank screen (1,000 ms), followed by a fixation cross (1,000 ms) that turned from black to red to indicate the beginning of a new trial. Then, a question appeared on the screen: *Is this body fatter than your own?* in the *Self* condition, or *Is this body fatter than average?* in the *Average* condition. Before the start of the task, we explained to participants that "average" means the most common/typical body for their age and gender (according to their best guess). The question was followed by a 1,000-ms test body selected by QUEST, from a set of possible stimuli based on their history of responses on previous trials. A blank screen remained visible until the response was made using labeled keyboard keys ("yes"/"no"). After the response, a black cross appeared on the screen for 1,000 ms indicating the end of the trial. Each part was divided in four blocks of 40 trials (two blocks per condition, ABBA order counterbalanced across participants). At the end of each block, the point of subjective equality (PSE, i.e., the stimulus for which the participant was equally likely to judge it as fatter or thinner) was calculated using QUEST. The PSEs from the two blocks were then averaged to obtain a single estimate for each condition, separately for the Baseline and the Adaptation phase.

The Adaptation phase started with an initial 2-min exposure to the thin adaptor. The adaptor flickered every 4 s (disappearing for 500 ms and appearing again) to maintain attention. After that, participants performed the same task as in the Baseline phase. Each trial in the Adaptation phase was identical to the Baseline with the addition of a thin body exposure. A very thin adaptor (BMI 13) was presented for 8 s to "top-up" the adaptation, followed by one second of blank screen, just before the presentation of the corresponding question (i.e., *is this body fatter than your own/average*) and the test stimulus. Again, the PSE was calculated after every block, resulting in two PSEs per condition.

Results

In each experimental session, two 50% thresholds (PSEs) per condition were calculated using QUEST to estimate the BMI at which participants were equally likely to respond thinner or fatter. These two PSEs were then averaged, resulting in four PSEs, one for each condition (*Self*, *Average*) and adaptation phase (*Baseline* and *Adaptation*). Our main effect of interest was *the pre-post adaptation shift* of the PSEs in Self and Other condition. The results are shown in **Figure 2** (left panel). Clear adaptation aftereffects were apparent in both conditions. In the Self condition, the mean perceived BMI decreased from 28.1 (SD = 2.3) at pre-test to 25.9 (SD = 2.8) after adaptation, Similarly, in the Average condition, mean judgments decreased from 28.5 (SD = 1.9) at pre-test to 26.3 (SD = 2.2) after adaptation. This clear decrease in perceived BMI from *Baseline* to *Adaptation* was significant, both in the *Self* condition (mean change: 2.22, SD: 1.24), $t(19) = 8.05$, $p < 0.001$, $d_z = 1.80$, and in the *Average* condition (mean change: 2.26, SD: 1.68), $t(19) = 6.00$, $p < 0.001$, $d_z = 1.34$.

To investigate the effects of the two judgment types, we conducted a 2 × 2 repeated measures analysis of variance (ANOVA) on the PSEs with factors *condition* (*Self / Average*) and *adaptation* (*Baseline / Adaptation*). We found a main effect of adaptation, $F(1, 19) = 50.78$, $p < 0.001$, $\eta_p^2 = 0.75$. That is, after adaptation to a thin adaptor, participants perceived as fatter, images that before adaptation were considered as thinner (see **Figure 2**). There was no effect of condition, $F(1, 19) = 0.74$, $p = 0.4$, $\eta_p^2 = 0.04$, suggesting that on

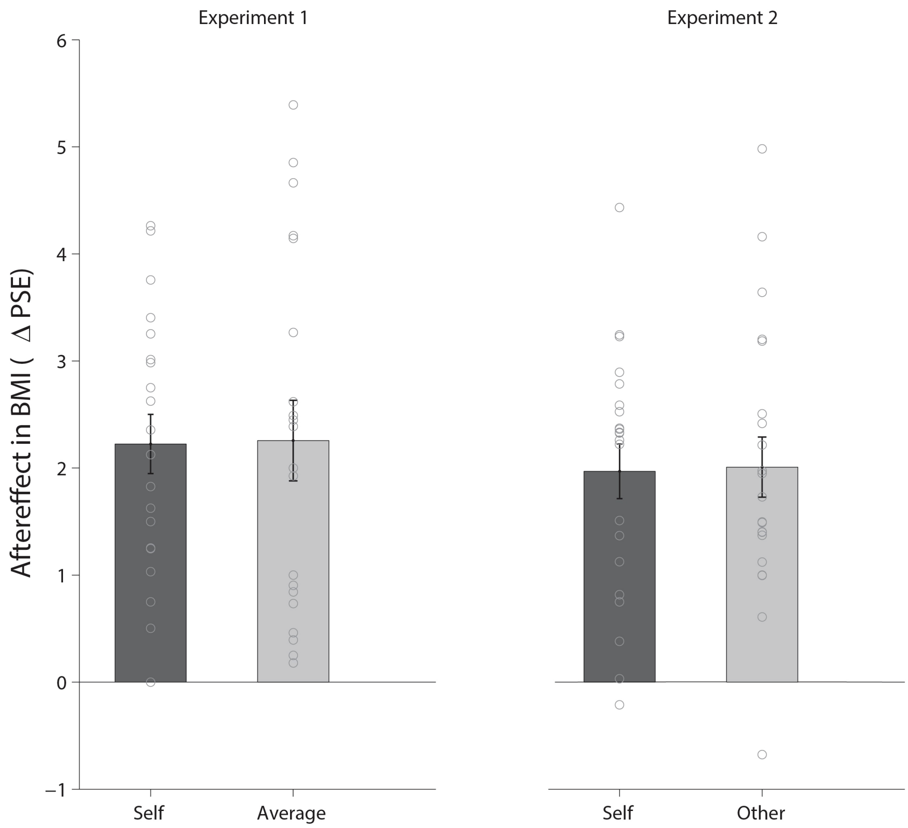

FIGURE 2 | Results of Experiments 1 (left panel) and 2 (right panel). (Left panel) The effect of adaptation for the *Self* and *Average* conditions shown as the pre-post adaptation shift in PSE. The dots indicate individual subjects, and the error bars represent standard errors. Clear adaptation aftereffects were apparent for both body image judgments in the *Self* condition and judgments of typicality in the *Average* condition. The magnitude of the aftereffects was very similar in the two conditions. (Right panel) The effect of adaptation for the *Self* and *Other* conditions presented in the same way as in Experiment 1.

average participants did not judge themselves as fatter or thinner than a typical woman. Critically, there was no interaction, $F(1, 19) = 0.026$, $p = 0.874$, $\eta_p^2 = 0.00$, suggesting that adaptation affected participants' perception of themselves in the same way it affected perception of typicality. Moreover, the magnitude of the aftereffects in both conditions was correlated across participants, $r = 0.85$, $p < 0.001$.

There was a correlation between participants' own BMI and the baseline PSEs in the Self condition: $r = 0.71$, $p < 0.001$, but not in the average condition: $r = 0.16$, $p = 0.500$. Similarly, after adaptation, there was a correlation between participants' own BMI and PSEs in the Self condition: $r = 0.69$, $p < 0.001$, but not in the Other condition: $r = 0.35$, $p = 0.128$. The clear correlation between actual and perceived BMI is important to note given that other tasks purporting to measure body image (such as the moving caliper method) have been criticized on the basis that no such correlations were apparent (e.g., Ben-Tovim and Crisp, 1984; Ben-Tovim et al., 1990).

To further compare the magnitude of the aftereffects in two conditions, we conducted a Bayesian paired *t*-test (Rouder et al., 2009), comparing the PSE change (Baseline/Adaptation) between conditions, which provided support for the null hypothesis, $BF_{(0,\ 0.7)} = 0.24$.

The absence of an overall effect of *Self* vs. *Average* condition may suggest that participants genuinely considered themselves as being about the average size, despite the fact that the average BMI of our participants (21.9) was lower than the UK average for females in the same age range, which was reported to be 25.9 (Health Survey for England, 2016). Alternatively, the results may suggest that participants did not perform different tasks in the two conditions and possibly used themselves as a reference in both. Experiment 2 aimed to address these issues.

EXPERIMENT 2

The results of Experiment 1 revealed no differences between the *Self* and *Average* conditions. This therefore did not allow us to conclude that participants actually performed two different tasks in those two conditions. In Experiment 2, instead of the *Average* condition we designed a condition (*Other*), in which participants had to compare test stimuli with a specific person, namely the experimenter (KBA) with whom participants interacted prior to performing the task. We reasoned that the use of a specific person rather than an abstract "average" person would make the task easier and clearer to the participants.

Methods

Participants

Twenty-one participants (mean age: 29.9, SD: 10, range: 19–58; mean BMI: 23.7, SD: 4.8, range 17.0–35.0) took part in Experiment 2. All participants had normal or corrected to normal vision. All participants gave informed consent and were paid for their participation. The procedures were approved by the ethics board of the Department of Psychological Sciences, Birkbeck, University of London.

Stimuli and Procedures

Stimuli were identical to Experiment 1. Procedures were similar to Experiment 1. This time, however, participants were asked to compare the images either with themselves, answering the question: *Is this body thinner or fatter than your own?*, or with the experimenter (KBA), answering the question: *Is this body thinner or fatter than Klaudia?* (*Other* condition). Before the start of the experiment, participants had approximately 5 min of visual experience of the experimenter while she introduced the task. The experimenter was wearing close-fitting clothes and after explaining the task, she stood in front of the participant and asked them to memorize her body size and shape for about 10 s. During the task, participants were not looking at the experimenter. As in Experiment 1, the experiment consisted of two parts: *Baseline* and *Adaptation*. Each part was divided into four blocks of 30 trials (two blocks per *Self/Other* condition, in ABAB order, counterbalanced across participants). To shorten the length of the experiment, the duration of the adapting stimuli was reduced to 6 s, and the duration of the initial blank screen and the fixation cross before and after the response was reduced to 500 ms each.

Results and Discussion

Results from Experiment 2 are shown in **Figure 2** (right panel). In the *Self* condition, mean perceived BMI decreased from 25.7 (SD = 3.4) at pre-test to 23.7 (SD = 3.8) after adaptation. Similarly, in the *Other* condition, PSEs decreased from 24.3 (SD = 1.7) at pre-test to 22.3 (SD = 1.9) after adaptation. Again, clear adaptation aftereffects were significant in both the *Self* condition (mean change: 1.97, SD: 1.17), $t(20) = 7.71$, $p < 0.001$, $d_z = 1.68$, and the *Other* condition (mean change: 2.01, SD: 1.29), $t(20) = 7.15$, $p < 0.001$, $d_z = 1.56$[1]. A 2 × 2 repeated measures ANOVA with factors condition and adaptation revealed a main effect of adaptation, $F(1,20) = 81.47$, $p < 0.0001$, $\eta_p^2 = 0.80$, showing that exposure to a thin body affected the perception of test bodies. We also found a significant main effect of condition, $F(1, 20) = 5.30$, $p = 0.032$, $\eta_p^2 = 0.21$, which reflects the fact that the experimenter was perceived differently (overall as thinner) than the participants perceived themselves. This difference between the two types of judgments is important as it demonstrates that participants were in fact making different judgments in the two conditions. Critically, however, there was no significant interaction, $F(1, 20) = 0.02$, $p = 0.9$, $\eta_p^2 = 0.00$, again suggesting that adaptation affected participants' perception of themselves in the same way it affected perception of the experimenter's body. As in Experiment 1, there was a positive correlation between the magnitude of the aftereffects in the two conditions, though it did not differ significantly from 0, $r = 0.35$, $p = 0.12$.

There was a correlation between participants' own BMI and the baseline PSEs in the Self condition: $r = 0.69$, $p < 0.001$, but not in the Other condition: $r = 0.08$, $p = 0.730$. After adaptation, there was a correlation between participants' own BMI in both conditions: $r = 0.72$, $p < 0.001$ in the Self condition and $r = 0.49$, $p = 0.024$ in the Other condition, respectively.

As in Experiment 1, a Bayesian paired t-test comparing the magnitude of the change in PSE in the two conditions provided additional support for the null hypothesis: $BF_{(0, 0.7)} = 0.23$, further suggesting that there is no difference in the magnitude of aftereffects between the *Self* and the *Other* condition.

These results showed that adaptation to an extremely thin body affected judgments about self vs. other body similarly and therefore the magnitude of the aftereffects was not influenced by the type of judgment being made. However, previous research suggested that in some cases body adaptation may be affected by the task. Winkler and Rhodes (2005) showed that while adaptation to a thin body had an effect on both perceived normality and attractiveness of test bodies, adaptation to a fat body did not significantly affect perceived attractiveness. In Experiment 3, we tested whether adaptation to fat bodies affected self vs. other body judgments equally.

One possible limitation of Experiment 2 is the fact that the experimenter was used as a reference in the Other condition. Although the pattern of results in this condition resembles typical adaptation aftereffects, it is possible that the responses were affected by some form of participant bias or social desirability bias in which participants change their responses to more socially acceptable. Since judging another person's weight is a sensitive task and participants knew that the experimenter would eventually see their responses, it is possible that they altered their judgments. Therefore, in Experiment 3, in which we tested the effect of both thin and fat exposure, we used a famous person (Kate Middleton) as a reference in the Other condition.

EXPERIMENT 3

Experiment 3 aimed to test the effect of thin and fat adaptation on judgments about self and other bodies. This time, in the *Other* condition, we used a famous person in the United Kingdom, i.e., Kate Middleton (the Duchess of Cambridge). We chose Kate Middleton as we expected that she would be familiar to a largest group of potential participants. In addition, KM has a BMI of about 18 which is lower than

[1]Because of a programming error, in some subjects, some of the PSEs that came close to the upper limit of possible stimuli could have suffered from a ceiling effect. In all cases, only one PSE per condition was affected (two were obtained), which made it possible to remove the affected PSEs in an additional analysis. Removing the affected PSEs (10.6% of all PSEs) did not change the overall pattern of the results. Imputing the affected PSEs using regression analysis also yielded very similar results.

that of an average UK female (and indeed lower than that of 90% of participants in Experiments 1 and 2), which made the difference between the conditions most apparent.

Methods

Participants

Eighteen participants took part in Experiment 3 (mean age: 27.1, SD: 7.3, range: 20–41; mean BMI: 20.2, SD: 2.2, range 17.0–25.4). Two additional participants who signed up for Experiment 3 were tested but their data were never analyzed. One of them was pregnant and the other one had a BMI beyond the range of our stimuli. All participants had normal or corrected to normal vision. All participants gave informed consent and were paid for their participation. The procedures were approved by the ethics board of the Department of Psychological Sciences, Birkbeck, University of London.

Stimuli and Procedures

Procedures were similar to those of Experiment 2. However, in the *Other* condition, participants were asked to compare the test images with Kate Middleton, answering the question: *Is this body thinner or fatter than Kate Middleton?* We made sure that all participants were familiar with the appearance of Kate Middleton prior to the experiment. Additionally, at the beginning of the experiment, participants were presented with five full body images of Kate Middleton.

Unlike the first two experiments which involved only a thin adapting stimulus, Experiment 3 included both a thin (BMI 13) and a fat adaptor (BMI 35). The experiment therefore consisted of four parts: Baseline and Adaptation, each repeated twice, once with a thin and once with a fat adaptor. Each of these four parts was further divided in four blocks of 36 trials (two blocks per *Self*/*Other* condition, in ABAB order, counterbalanced across participants). To further reduce the length of the experiment, initial adaptation was shortened to 1 min, the top-up adaptation to 4 s, and the initial blank screen to 250 ms. Participants took a 10-min break between the two adaptation procedures (i.e., thin and fat) to allow the effect of adaptation to wear off. The order of thin/fat adaptation was counterbalanced across participants.

Results and Discussion

The results from Experiment 3 are shown in **Figure 3**. After adaptation to a thin body, in the *Self* condition, the mean perceived BMI dropped from 23.8 (SD = 2.6) at pre-test to 21.0 (SD = 3.0) after adaptation. In the *Other* (i.e., Kate Middleton) condition, perceived BMI dropped from 21.97 (SD = 1.7) at pre-test to 19.11 (SD = 1.24) after adaptation. As in the first two experiments, clear aftereffects were apparent in both the *Self* condition (mean change: 2.78, SD: 1.71), $t(17) = 6.89$, $p < 0.001$, $d_z = 1.63$, and the *Other* (i.e., Kate Middleton) condition (mean change: 2.86, SD: 1.39), $t(17) = 8.76$, $p < 0.001$, $d_z = 2.07$. Similar aftereffects were also found after adaptation to a fat body. In the Self condition, the mean perceived BMI increased from 22.6 (SD = 2.3) at pre-test to 25.4 (SD = 2.4) after adaptation. In the Other condition,

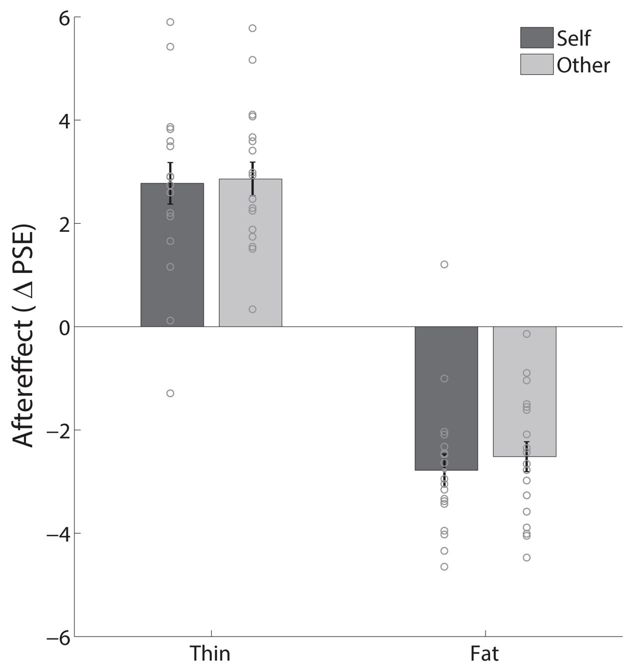

FIGURE 3 | Results of Experiment 3. The effect of thin and fat adaptation for *Self* and *Other* condition. The gray dots indicate individual subjects and the error bars represent standard errors.

perceived BMI increased from 21.5 (SD = 1.6) at pre-test to 24.0 (SD = 1.8) after adaptation. There were clear increases in judged BMI in the *Self* condition (mean change: −2.78, SD: 1.34), $t(17) = -8.76$, $p < 0.001$, $d_z = 2.07$, and the *Other* condition (mean change: −2.51, SD: 1.23), $t(17) = -8.67$, $p < 0.001$, $d_z = 2.04$. Thus, clear aftereffects were found for both thin and fat adapting stimuli, both for judgments of one's own body and of Kate Middleton's body.

A 2 × 2 × 2 repeated measures ANOVA with factors *condition* (*Self*/*Other*), *adaptation* (*Baseline*/*Adaptation*), and *adapting body type* (thin/fat) was performed on the PSEs. We found no main effect of adaptation, $F(1,17) = 0.22$, $p = 0.644$, $\eta^2_p = 0.01$. There was, however, a main effect of adapting body type, $F(1,17) = 102.34$, $p < 0.001$, $\eta^2_p = 0.86$, and an interaction between adaptation and adapting body type, $F(1,17) = 187.26$, $p < 0.001$, $\eta^2_p = 0.92$, showing that adaptation to thin vs. fat bodies produced strong effects in opposite directions. We tested this assumption using two-tailed paired *t* tests directly comparing results of adaptation sessions to thin vs. fat: $t(17) = -11.78$, $p < 0.0001$, $d_z = -2.72$ for the *Self* condition, and $t(17) = -12.25$, $p < 0.0001$, $d_z = -2.89$ for the *Other* condition. We also found a main effect of *Self*/*Other* condition, $F(1,17) = 11.65$, $p = 0.003$, $\eta^2_p = 0.41$, clearly indicating that participants in the study perceived their bodies as different from Kate Middleton's (overall as fatter). The interaction between the *Self*/*Other* condition and the adapting body type (thin/fat) was also significant, $F(1,17) = 5.76$, $p = 0.028$, $\eta^2_p = 0.25$. However, again there was no interaction between adaptation and *Self*/*Other* condition, $F(1,17) = 0.306$, $p = 0.587$, $\eta^2_p = 0.018$, and no interaction between all three factors, $F(1,17) = 0.132$, $p = 0.721$, $\eta_p^2 = 0.08$. This indicates that adaptation affects participants' judgments of themselves in the same way it affected judgments of Kate Middleton's body. As in Experiments 1 and 2, there was a positive correlation between the magnitude of the aftereffects in the two conditions, though it did not differ significantly from 0: $r = 0.33$, $p = 0.18$ for the thin adaptation and $r = 0.22$, $p = 0.38$ for the fat adaptation.

In the thin adaptation, there was a correlation between participants' own BMI and the baseline PSEs in the Self condition: $r = 0.66$, $p = 0.003$, but not in the Other condition: $r = 0.20$, $p = 0.426$. Similarly, after adaptation, there was a correlation between participants' own BMI and PSEs in the Self condition: $r = 0.77$, $p < 0.001$, but not in the Other condition: $r = 0.25$, $p = 0.308$. In fat adaptation, there was a correlation between participants' own BMI and the baseline PSEs in the Self condition: $r = 0.72$, $p < 0.001$, but not in the Other condition: $r = 0.03$, $p = 0.906$. Similarly, after adaptation there was a correlation between participants' own BMI and PSEs in the Self condition: $r = 0.70$, $p = 0.001$, but not in the Other condition: $r = 0.05$, $p = 0.845$.

Again, the results of the Bayesian paired *t*-test comparing the magnitude of the aftereffects in two conditions showed that data support the null hypothesis for both, thin adaptor, $BF_{(0,\ 0.7)} = 0.25$, and fat adaptor, $BF_{(0,\ 0.7)} = 0.30$.

GENERAL DISCUSSION

Body dissatisfaction is a prevalent problem in modern societies (Grogan, 2017). Media are often blamed for creating unrealistic, unhealthy body ideals that can shape our beliefs and attitudes (Derenne and Beresin, 2006). Recently, it has also been suggested that exposure to thin ideals can influence the way we actually perceive our own bodies. Several studies (Hummel et al., 2012b; Brooks et al., 2016) proposed visual adaptation as a model of media influences on one's own body image. Our results replicate previous results showing that visual adaptation to extreme body types affects body image judgments. Critically, however, virtually identical effects were found for judgments of other people's bodies. This suggests that adaption does not have specific effects on the participant's body image. We suggest instead that adaptation may have affected body types of judgment by changing visual perception of the test stimuli. Here, we showed that adaptation affects judgments about one's own body in a similar way as judgments about other people's bodies, both when asking about typical bodies (Experiment 1), or about a specific other person's body (Experiments 2 and 3). Importantly, we found a main effect of *Self/Other* condition in Experiments 2 and 3, indicating that people were indeed performing different tasks when comparing the test stimuli with either their own body or bodies of others.

Our findings are consistent with the results of previous studies that reported transfer of body size aftereffects between different identities (Hummel et al., 2012b; Brooks et al., 2016). The authors of these studies suggest that their results reflect perceptual bias similar to those evoked by exposure to thin ideals in Western culture and that this bias may contribute to the development of body image disorders. It is true that for visual adaptation to constitute an experimental model of body image distortion, some overlap of the representation of self and others is required to allow the transfer of aftereffects from media images to the perception of one's own body. However, if visual adaptation to bodies truly modulates one's own body image, then it should also differ from the general effect adaptation has on all images of bodies. If both the item being tested (own body) and the probe (other bodies) are equally affected by adaptation, the relative difference between them should not change. If all bodies are equally affected, adaptation to extreme body types cannot serve as a sufficient explanation for own body image distortion. If, however, adaptation affects perception of one's own body and other bodies differently, it may suggest that it affects higher level representation of one's own body and not only the experience of the visual image. Here, we found equally strong aftereffects for judgments about one's own body and other people's bodies. Thus, our results provide no evidence that body size adaptation has an effect that shows specificity to one's body image.

Brooks et al. (2016) showed stronger body size aftereffects when the identity between the adaptor and test stimuli matched, regardless of whether both corresponded to images of the participant's own body or the body of an unknown other. Nonetheless, they also found some transfer in body size aftereffects between identities, so that adaptation to a fat or thin body of an unknown other affected the perception of images of their own body at test, and vice versa. These effects suggest a partial dissociation of the neural mechanisms encoding body size for self and other. However, as noted by the authors themselves, the use of only two identities ("own body" and "the body of an unfamiliar other") does not allow to rule out the possibility that the observed effects are not specific to the self, but rather would have been observed regardless of the two specific identities used. In the present study, we address this issue by requesting judgments about the same test stimuli throughout, but using as criteria different internal representations (i.e., an image of the body self or the body of another person), varying, therefore, the context. Interestingly, Winkler and Rhodes (2005) found that attractiveness aftereffects were observed following adaptation to extremely thin bodies but not following adaptation to fat bodies, whereas no such asymmetry was found when participates were asked to judge the perceived normality of the test image. This asymmetry suggests that strength of adaptation aftereffects in some cases may be mediated by the context of the task. Furthermore, de la Rosa et al. (2014) found modulation of action adaptation aftereffects across two conditions that had identical adapting and test stimuli but differed with respect to the information that was provided prior to the adaptation, i.e., the social context. However, in our study, the context of the specific judgment being made (i.e., about one's own body or about someone else's) did not affect the magnitude of the adaptation aftereffects.

There are some clear limitations of the present study. Our study reports null findings, which have an ambiguous status in the field, not allowing to draw very strong conclusions. However, we found consistent results across experiments and in all three experiments, we report Bayes factors that provided moderate support in favor of the null hypothesis. Furthermore, the use of only a single identity stimuli meant that adaptation in our study was specific to this identity (see Brooks et al., 2016). Future studies should further investigate this topic using multiple identities that share only the property of adiposity.

Our study investigated short-term effects of relatively short adaptation period (a couple of minutes). It is possible that longer term adaptation affects body representations in a way that goes beyond pure visual perception. One of the main characteristics of both low-level and high-level perceptual aftereffects is that their magnitude depends on the length of adaptation (Leopold et al., 2005). Recent research on lower level visual adaptation aftereffects has suggested that there may be qualitatively distinct mechanisms that underlie adaptation over very short-term and longer term time scales (e.g., Vul et al., 2008; Bao and Engel, 2012; Bao et al., 2013). It is therefore possible that long-term exposure to extreme body types could produce a different pattern of results to those we found in this study. Future studies should examine whether prolonged visual adaptation can cause aftereffects in another modality, related to body representation, e.g., touch.

Our results also do not allow us to distinguish whether the aftereffects we report reflect changes in the actual perception of body stimuli or higher level decisional processes used to make judgments about these stimuli. Recent work has suggested that many effects previously interpreted as perceptual may actually reflect decisional processes (e.g., Morgan et al., 2011; Firestone and Scholl, 2013). The psychophysical methods used in this study, like nearly all other studies of "high-level" adaptation aftereffects, do not allow these interpretations to be distinguished (cf. Storrs, 2015).

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the ethics board of the Department of Psychological Sciences, Birkbeck, University of London, with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the ethics board of the Department of Psychological Sciences, Birkbeck, University of London.

AUTHOR CONTRIBUTIONS

KA, EA, and ML designed the study and wrote the manuscript. KA collected the data. KA analyzed the data under supervision of EA and ML.

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REFERENCES

Anstis, S., Verstraten, F. A. J., and Mather, G. (1998). The motion aftereffect. *Trends Cogn. Sci.* 2, 111–117. doi: 10.1016/S1364-6613(98)01142-5

Bao, M., and Engel, S. A. (2012). Distinct mechanisms for long-term contrast adaptation. *Proc. Natl. Acad. Sci. USA* 109, 5898–5903. doi: 10.1073/pnas.1113503109

Bao, M., Fast, E., Mesik, J., and Engel, S. A. (2013). Distinct mechanisms control contrast adaptation over different timescales. *J. Vis.* 13:14. doi: 10.1167/13.10.14

Barlow, H. B., and Hill, R. M. (1963). Evidence for a physiological explanation of the waterfall illusion. *Nature* 200, 1345–1347. doi: 10.1038/2001345a0

Ben-Tovim, D. I., and Crisp, A. H. (1984). The reliability of estimates of body width and their relationship to current measured body size among anorexic and normal subjects. *Psychol. Med.* 14, 843–846. doi: 10.1017/S0033291700019814

Ben-Tovim, D. I., Walker, M. K., Murray, H., and Chin, G. (1990). Body size estimates: body image or body attitude measure? *Int. J. Eat. Disord.* 9, 57–67. doi: 10.1002/1098-108X(199001)9:1<57::AID-EAT2260090107>3.0.CO;2-S

Boothroyd, L. G., Tovee, M. J., and Pollet, T. V. (2012). Visual diet versus associative learning as mechanisms of change in body size preferences. *PLoS One* 7:e48691. doi: 10.1371/journal.pone.0048691

Bould, H., Carnegie, R., Allward, H., Bacon, E., Lambe, E., Sapseid, M., et al. (2018). Effects of exposure to bodies of different sizes on perception of and satisfaction with own body size: two randomised studies. *R. Soc. Open Sci.* 5:171387. doi: 10.1098/rsos.171387

Brainard, D. H. (1997). The psychophysics toolbox. *Spat. Vis.* 10, 433–436. doi: 10.1163/156856897X00357

Brooks, K., Clifford, C. W. G., Stevenson, R. J., Mond, J., and Stephen, I. D. (2018). The high level basis of body adaptation. *R. Soc. Open Sci.* 5, 1–9. doi: 10.1098/rsos.172103

Brooks, K. R., Mond, J. M., Stevenson, R. J., and Stephen, I. D. (2016). Body image distortion and exposure to extreme body types: contingent adaptation and cross adaptation for self and other. *Front. Neurosci.* 10:334. doi: 10.3389/fnins.2016.00334

Challinor, K. L., Mond, J., Stephen, I. D., Mitchison, D., Stevenson, R. J., Hay, P., et al. (2017). Body size & shape misperception and visual adaptation: an overview of an emerging research paradigm. *J. Int. Med. Res.* 45, 2001–2008. doi: 10.1177/0300060517726440

Cornelissen, P. L., Cornelissen, K. K., Groves, V., McCarty, K., and Tovée, M. J. (2018). View-dependent accuracy in body mass judgements of female bodies. *Body Image* 24, 116–123. doi: 10.1016/j.bodyim.2017.12.007

Cornelissen, P. L., Toveé, M. J., and Bateson, M. (2009). Patterns of subcutaneous fat deposition and the relationship between body mass index and waist-to-hip ratio: implications for models of physical attractiveness. *J. Theor. Biol.* 256, 343–350. doi: 10.1016/j.jtbi.2008.09.041

de la Rosa, S., Streuber, S., Giese, M., Bülthoff, H. H., and Curio, C. (2014). Putting actions in context: visual action adaptation aftereffects are modulated by social contexts. *PLoS One* 9:86502. doi: 10.1371/journal.pone.0086502

Derenne, J. L., and Beresin, E. V. (2006). Body image, media, and eating disorders. *Acad. Psychiatry* 30, 257–261. doi: 10.1176/appi.ap.30.3.257

Firestone, C., and Scholl, B. J. (2013). "Top-down" effects where non should be found: the El Greco fallacy in perception research. *Psychol. Sci.* 25, 38–46. doi: 10.1177/0956797613485092

Fox, C. J., and Barton, J. J. S. (2007). What is adapted in face adaptation? The neural representations of expression in the human visual system. *Brain Res.* 1127, 80–89. doi: 10.1016/j.brainres.2006.09.104

Garner, D. M., Garfinkel, P. E., Stancer, H. C., and Moldofsky, H. (1976). Body image disturbances in anorexia nervosa and obesity. *Psychosom. Med.* 38, 327–336. doi: 10.1097/00006842-197609000-00005

Gibson, J. J., and Radner, M. (1937). Adaptation, after-effect and contrast in the perception of tilted lines. I. Quantitative studies. *J. Exp. Psychol.* 20, 453–467. doi: 10.1037/h0059826

Glauert, R., Rhodes, G., Byrne, S., Fink, B., and Grammer, K. (2009). Body dissatisfaction and the effects of perceptual exposure on body norms and ideals. *Int. J. Eat. Disord.* 42, 443–452. doi: 10.1002/eat.20640

Groesz, L. M., Levine, M. P., and Murnen, S. K. (2002). The effect of experimental presentation of thin media images on body satisfaction: a meta-analytic review. *Int. J. Eat. Disord.* 31, 1–16. doi: 10.1002/eat.10005

Grogan, S. (2017). *Body image: Understanding body dissatisfaction in men, women and children. 3rd Edn*. New York, NY: Routledge.

Guardia, D., Conversy, L., Jardri, R., Lafargue, G., Thomas, P., Dodin, V., et al. (2012). Imagining one's own and someone else's body actions: dissociation in anorexia nervosa. *PLoS One* 7, 1–9. doi: 10.1371/journal.pone.0043241

Health Survey for England (2003). National Centre for Social Research and University College London. Department of Epidemiology and Public Health. Colchester, Essex: UK Data Archive.

Health Survey for England (2016). NHS Digital. National Centre for Social Research, University College London, Department of Epidemiology and Public Health. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/health-survey-for-england-2016

Horndasch, S., Heinrich, H., Kratz, O., Mai, S., Graap, H., and Moll, G. H. (2015). Perception and evaluation of women's bodies in adolescents and adults with anorexia nervosa. *Eur. Arch. Psychiatry Clin. Neurosci.* 265, 677–687. doi: 10.1007/s00406-015-0603-3

Hummel, D., Grabhorn, R., and Mohr, H. M. (2012a). Body-shape adaptation cannot be explained by adaptation to narrow and wide rectangles. *Perception* 41, 1315–1322. doi: 10.1068/p7197

Hummel, D., Rudolf, A. K., Brandi, M.-L., Untch, K.-H., Grabhorn, R., Hampel, H., et al. (2013). Neural adaptation to thin and fat bodies in the fusiform body area and middle occipital gyrus: an fMRI adaptation study. *Hum. Brain Mapp.* 34, 3233–3246. doi: 10.1002/hbm.22135

Hummel, D., Rudolf, A. K., Untch, K. H., Grabhorn, R., and Mohr, H. M. (2012b). Visual adaptation to thin and fat bodies transfers across identity. *PLoS One* 7, 1–6. doi: 10.1371/journal.pone.0043195

JASP Team (2017). JASP (Version 0.8.1.1) [Computer software].

Leopold, D. A., Rhodes, G., Muller, K.-M., and Jeffery, L. (2005). The dynamics of visual adaptation to faces. *Proc. R. Soc. B* 272, 897–904. doi: 10.1098/rspb.2004.3022

Longo, M. R. (2015). Implicit and explicit body representations. *Eur. Psychol.* 20, 6–15. doi: 10.1027/1016-9040/a000198

Longo, M. R., Azañón, E., and Haggard, P. (2010). More than skin deep: body representation beyond primary somatosensory cortex. *Neuropsychologia* 48, 655–668. doi: 10.1016/j.neuropsychologia.2009.08.022

McCollough, C. (1965). Color adaptation of edge-detectors in the human visual system. *Science* 149, 1115–1116. doi: 10.1126/science.149.3688.1115

Mizes, J. S. (1992). The body image detection device versus subjective measures of weight dissatisfaction: a validity comparison. *Addict. Behav.* 17, 125–136. doi: 10.1016/0306-4603(92)90017-P

Morgan, M., Fillenberger, B., Raphael, S., and Solomon, J. A. (2011). Observers can voluntarily shift their psychometric functions without losing sensitivity. *Atten. Percept. Psychophysiol.* 74, 185–193. doi: 10.3758/s13414-011-0222-7

Øverås, M., Kapstad, H., Brunborg, C., Landrø, N. I., and Lask, B. (2014). Memory versus perception of body size in patients with anorexia nervosa and healthy controls. *Eur. Eat. Disord. Rev.* 22, 109–115. doi: 10.1002/erv.2276

Pond, S., Kloth, N., McKone, E., Jeffery, L., Irons, J., and Rhodes, G. (2013). Aftereffects support opponent coding of face gender. *J. Vis.* 13:16. doi: 10.1167/13.14.16

Rhodes, G., Jeffery, L., Watson, T. L., Clifford, C. W. G., and Nakayama, K. (2003). Fitting the mind to the world: face adaptation and attractiveness aftereffects. *Psychol. Sci.* 14, 558–566. doi: 10.1046/j.0956-7976.2003.psci_1465.x

Rouder, J. N., Speckman, P. L., Sun, D., Morey, R. D., and Iverson, G. (2009). Bayesian t tests for accepting and rejecting the null hypothesis. *Psychon. Bull. Rev.* 16, 225–237. doi: 10.3758/PBR.16.2.225

Schilder, P. (1935/1950). *The image and appearance of the human body*. New York, NY: International Universities.

Schneider, N., Frieler, K., Pfeiffer, E., Lehmkuhl, U., and Salbach-Andrae, H. (2009). Comparison of body size estimation in adolescents with different types of eating disorders. *Eur. Eat. Disord. Rev.* 17, 468–475. doi: 10.1002/erv.956

Slade, P. D., and Russell, G. F. (1973). Awareness of body dimensions in anorexia nervosa: cross-sectional and longitudinal studies. *Psychol. Med.* 3, 188–199. doi: 10.1017/S0033291700048510

Stephen, I. D., Sturman, D., Stevenson, R. J., Mond, J., and Brooks, K. R. (2018). Visual attention mediates the relationship between body satisfaction and susceptibility to the body size adaptation effect. *PLoS One* 13:e0189855. doi: 10.1371/journal.pone.0189855

Storrs, K. R. (2015). Are high-level aftereffects perceptual? *Front. Psychol.* 6:157. doi: 10.3389/fpsyg.2015.00157

Thompson, J. K., Berland, N. W., Linton, P. H., and Weinsier, R. L. (1986). Utilization of a self-adjusting light beam in the objective assessment of body distortion in seven eating disorder groups. *Int. J. Eat. Disorder.* 5, 113–120. doi: 10.1002/1098-108X(198601)5:1<113::AID-EAT2260050110>3.0.CO;2-D

Tiggemann, M., and McGill, B. (2004). The role of social comparison in the effect of magazine advertisements on women's mood and body dissatisfaction. *J. Soc. Clin. Psychol.* 23, 23–44. doi: 10.1521/jscp.23.1.23.26991

Tovée, M. J., Emery, J. L., and Cohen-Tovée, E. M. (2000). The estimation of body mass index and physical attractiveness is dependent on the observer's own body mass index. *Proc. R. Soc. Lond. B* 267, 1987–1997. doi: 10.1098/rspb.2000.1240

Vul, E., Krizay, E., and MacLeod, D. I. (2008). The McCollough effect reflects permanent and transient adaptation in early visual cortex. *J. Vis.* 8:4. doi: 10.1167/8.12.4

Watson, A. B., and Pelli, D. G. (1983). QUEST: a Bayesian adaptive psychophysical method. *Percept. Psychophys.* 33, 113–120. doi: 10.3758/BF03202828

Webster, M. A., Kaping, D., Mizokami, Y., and Duhamel, P. (2004). Adaptation to natural facial categories. *Nature* 428, 557–561. doi: 10.1038/nature02420

Winkler, C., and Rhodes, G. (2005). Perceptual adaptation affects attractiveness of female bodies. *Br. J. Psychol.* 96, 141–154. doi: 10.1348/000712605X36343

Wohlgemuth, A. (1911). On the aftereffect of seen movement. *Br. J. Psychol.* 1(Monograph Suppl. 1), 1–117.

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BRIEF RESEARCH REPORT
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A Brief Mobile Evaluative Conditioning App to Reduce Body Dissatisfaction? A Pilot Study in University Women

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Objective: Body dissatisfaction is a major risk factor underlying vulnerability to eating disorders. Experimental studies conducted in controlled environments suggest that body dissatisfaction could be improved by using evaluative conditioning (EC). The present study evaluates the feasibility of using an EC app in everyday life and the effects of its use on body dissatisfaction.

Method: We designed a game-like app inspired by the Therapeutic EC app. 60 participants were randomly assigned to two conditions. Participants in the EC condition had to pair photographs of their own body with positive photographs, while participants in the neutral condition had to pair photographs of their own body with neutral photographs. We tested the effect of use of the app on body dissatisfaction, drive for thinness, self-esteem, depressive symptoms and eating behaviors.

Results: Analysis revealed that participants in all conditions presented a significant decrease in body dissatisfaction, drive for thinness and an increase in self-esteem. However, contrary to our hypothesis, these effects were no greater in the EC condition than in the neutral condition.

Conclusion: This is the first study to evaluate the effects of an app-based EC intervention targeting body image. Results appear to be promising and the app could easily be implemented in an ecological setting as it is a low effort, attractive and accessible intervention. However, the findings question the idea that EC was responsible for the observed effects which could be explained by the exposure effect. Results are discussed.

Keywords: evaluative conditioning, app, exposure, body dissatisfaction, prevention

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INTRODUCTION

Body dissatisfaction consists of dysfunctional, negative beliefs and feelings about one's weight and shape (Garner, 2002). Body dissatisfaction is a widespread and stable phenomenon across the population, particularly in women. Body dissatisfaction is studied because it is associated with numerous negative outcomes and is considered a major risk factor for various psychopathologies (Stice et al., 2011). As a consequence, eating disorder prevention programs address, among others, body dissatisfaction as part of their content (for a review see Littleton and Ollendick, 2003).

Many processes may lead to body dissatisfaction. For example, by conveying a thin ideal of beauty, the socio-cultural environment (family, peers, and the media) may contribute to the development and maintenance of body dissatisfaction (Thompson and Heinberg, 1999). Women who do not achieve ideal thinness would perceive this as a failure resulting in body dissatisfaction (Myers and Crowther, 2007). Body dissatisfaction could also result from social comparison, when the comparison is unfavorable (Tiggemann and McGill, 2004). Lastly, the discrepancy between the current body and an ideal body may lead to rumination about weight and shape, which in turn maintains body dissatisfaction (Etu and Gray, 2010; Maraldo et al., 2016). These different processes may lead to recurrent negative thinking about one own's body.

Various studies have examined how body dissatisfaction could be improved. Among these studies, experimental research conducted in laboratory settings suggests that body dissatisfaction could be improved by using evaluative conditioning (EC).

Evaluative conditioning can be considered a form of pavlovian conditioning (PC). PC corresponds to a change in behavior that results from the pairing of an unconditioned stimulus (US, e.g., electric shock) with a conditioned stimulus (CS, e.g., light). This pairing results in a change in behavior in response to the CS (e.g., defensive preparatory response). The same methodology (CS-US pairing) is used to study EC. The only difference between these two forms of learning is that EC procedures are only interested in the changes in appreciation of the CS. The EC effect is defined as a change in the pleasantness of a conditioned stimulus (CS) resulting from its association with a valenced stimulus (unconditioned stimulus; US) (De Houwer, 2007).

Evaluative conditioning is now considered a meaningful way to create and change implicit and explicit evaluations. One important property of EC is its resistance to extinction. Whereas most conditioned responses are typically reduced by presentations of the CS without the US, several studies have shown that EC is unaffected by unreinforced CS presentations (e.g., Hermans et al., 2002). In other words, when a stimulus has become negatively perceived through association with a negative US, it will remain so, even if it is no longer paired with the US. While there are still some debates regarding the mechanisms underlying the EC effect, there is strong support for the idea that EC depends on non-automatic processes. Indeed, EC has been shown to depend on the memory of the CS-US pairing (contingency awareness), attention, goal, and cognitive resources (Gast et al., 2012). EC has been demonstrated with a wide range of stimuli (e.g., pictures, odors, and flavors) in many fields of psychology (e.g., consumer science, social psychology, and learning psychology) with a variety of procedures.

Recently, EC has been used to study clinical phenomena like body dissatisfaction, in order to change problematic acquired valences. Jansen et al. (2008) proposed that negative thinking related to the body can be considered an US and the body can be considered a CS. Thus, recurrent negative thinking about one own's body, or negative feedback about body shape could result in multiple associations between one's body and negative information resulting in an EC effect. Thus, theoretically, one could change a negative evaluation of one's body through new associations with positive stimuli (counter-conditioning).

Martijn et al. (2010) used a computerized game in which the participant's task was to click on a photograph of a body presented at one of the four corners of the screen. Some photographs were of unknown people, others corresponded to the participants' own body (CS). In the experimental condition, when participants clicked on a photograph of their own body, a smiling face (US) appeared on the computer screen. They observed that women with high body concern demonstrated a decrease in body dissatisfaction and an increase in self-esteem. More recently, in a replication study, Glashouwer et al. (2019) found similar results. After the training in the experimental condition, participants rated pictures of their own body as more positive than participants in the control condition. However, the EC effect was only present for these pictures and did not transfer to self-report on body satisfaction. Moreover, women with high and low body concern did not benefit differentially from the EC. Finally, Aspen et al. (2015) observed that such a procedure also allowed a decrease in weight and shape concern and a reduction in self-reported restrictive eating in women with high body dissatisfaction. These changes were maintained at 12-week follow-up.

These results are particularly encouraging as EC procedures seem to be effective in countering body dissatisfaction, at least in non-clinical samples. However, some limitations still need to be overcome. Indeed, apart from a study by Glashouwer et al. (2018) which used an online EC procedure on a clinical sample (and did not find an effect of the intervention), experimental interventions based on EC targeting body dissatisfaction are currently restricted to controlled laboratory situations (participants are trained in laboratories, they wear standardized clothes). Technologies allowing laboratory methodologies to be easily delivered in the everyday world are needed.

Recently, Franklin et al. (2016) tested a brief game-like mobile app, designed to decrease self-injurious behavior and increase self-esteem. Participants were trained to associate self-related words to positive pictures and self-injury related stimuli to negative pictures using their smartphones. Results showed that the EC procedure led to a reduction in self-injurious thoughts and behaviors. These findings suggest that EC can be effective in changing the evaluation of stimuli directly in the ecological environment of participants. Kollei et al. (2017) recently found evidence that an app-based intervention (using approach-avoidance training) may significantly reduce body dissatisfaction. The present experiment constituted a pilot study to test the possibility of using an app-based EC procedure to induce change in body dissatisfaction in a non-clinical sample. This is the first time that an app using EC is tested to counter body dissatisfaction.

MATERIALS AND METHODS

Participants and Design

Participants were 60 French-speaking undergraduate women Mean Age = 19.55(1.36); Mean BMI = 22.09(4.39) from a

French University. The design of the study included assessment time (pre-test vs. post-test) as a two-level within-subject factor and condition (EC vs. neutral) as a two-level between-subject factor. Participants were randomly assigned to either the neutral condition (n = 30) or the EC condition. Group assignments were predetermined by subject number, odd numbered participants were assigned to the EC condition, even numbered participants were assigned to the neutral condition. The procedure was in accordance with the World Medical Association's Declaration of Helsinki and was approved by the local ethics committee (2017-01-57).

Material

Unconditioned Stimuli (USs)

Body dissatisfaction is supposed to rely on one's own evaluations, but also depends on the perceived approval of other people. Thus, previous experiments paired participants' own bodies with smiling faces. We decided to use a methodology similar to those used in previous experiments. Our 21 USs consisted of positive photographs. Each US+ corresponded to smiling women's faces of different ages and skin color. Each photograph had been pretested to (a) elicit a positive affective response and to (b) correspond to "ordinary people" and not to a feminine ideal (e.g., photoshopped models seen in advertising; see example **Figure 1**). This last choice was made to avoid the social comparison effect which could increase body dissatisfaction (Tiggemann and McGill, 2004).

Neutral Stimuli (NSs)

Our 21 NSs consisted of neutral photographs. These NSs corresponded to photographs of neutral objects from everyday life (e.g., keys, chair, door handles, and rubber bands). Each photograph had been selected from a pretest to (a) elicit a neutral affective response and to (b) not be related to eating or beauty (see example **Figure 1**).

All photographs were Creative Commons Zero images found on the Internet.

Conditioned Stimuli (CSs)

Three photographs of each participant were taken by experimenters and were used as CSs. One photograph was of the participant's face, two photographs were of the participant's full body (front and profile) wearing their own clothes.

Intervention

For the EC condition, we designed a brief game-like app, inspired by the app designed by Franklin et al. (2016). In our study, each game session began with the presentation of three different pairs of photographs that the participant was instructed to remember. Pairs were composed of one CS and one US+. CS-US+ associations were randomly determined by the app at the beginning of each session. During the game, at each trial, one of these three pairs appeared among distractor photographs. The participant's task was to select these pairs as quickly as possible. Distractor photographs corresponded to other USs+. Each game session contained 60 trials. At the end of each trial, the participant received feedback about the accuracy of the response (a red or green screen for 100 ms). Every 15 trials, the game became harder as more distractors were added and other response options were blacked out when the first option was selected (see **Figure 2**). Points were awarded for fast and accurate responses; this score was displayed at the end of each session. Thus, at each trial, participants associated an image of their body and a specific US+ by successively selecting a photograph of their own body and the target US+ (sequential pairing). Moreover, each time a participant saw a photograph of their own body, this was accompanied by other USs+ (distractors) on the screen

FIGURE 1 | USs+examples on the top line, USsNexamples on the bottom line.

FIGURE 2 | Screenshots of app for the EC condition. Shapes were replaced by participants pictures in the real app. Step 1: The sessions begin with a screen displaying pairs to learn. Step 2: Game session begins with 2 × 2 grid for the first 15 trials. Step 3: Alternative options are masked after the first pair member is selected for the second 15 trials. Step 4: Grid moves to a 2 × 4 grid for the third 15 trials. Step 5: Alternative options are masked after the first pair member is selected for the last 15 trials.

(simultaneous pairing). This constituted an EC procedure in which the participant's body was paired with pleasant stimuli in several ways.

For the neutral condition, the same methodology was applied, however, NSs were used instead of positive stimuli (USs+).

Eating Disorder Inventory-2

The EDI-2 (Garner, 1991; French version: Criquillon-Doublet et al., 1995) measures eating disorder symptoms and associated psychological traits. In this study we focused on attitudes and behaviors concerning eating, weight, and shape. Thus, we only used the 23 items in the subscales measuring drive for thinness, bulimia and body dissatisfaction. These items were adapted to only take the last 7 days into account. In our sample, Cronbach's Alpha (internal consistency) of the EDI-2 subscales drive for thinness and body dissatisfaction were, respectively 0.75 and 0.90 at pre-test and 0.81 and 0.92 at post-test. Cronbach's Alpha for the bulimia subscale at post-test was 0.80.

Contour Drawing Rating Scale

The CDRS (Thompson and Gray, 1995) consists of nine drawings of a female figure (for female participants). Each drawing increases in size from extremely thin to very obese. Participants are asked to rate their ideal figure and their current size (perceived figure). The discrepancy between ideal and current size scores constitutes an index of body size dissatisfaction.

Eating Disorder Examination Questionnaire

The *EDE-Q* (Fairburn and Beglin, 1994; French version: Mobbs and Van der Linden, unpublished) measures eating disorder psychopathology over the last 28 days. In this study we only used the five items of the Restraint subscale. These items were adapted to only take the last 7 days into account. In our sample, Cronbach's Alpha of EDE-Q was 0.85.

Center for Epidemiologic Studies Depression

The CES-D (Radloff, 1977; French version: Bouvard et al., 2013) consists of 20 items that measure depressive symptomatology in the general population. In our sample, Cronbach's Alpha of CES-D at pre-test and post-test were, respectively 0.92 and 0.94.

Rosenberg Self-Esteem Scale

The RSES (Rosenberg, 1965; French version: Vallieres and Vallerand, 1990) consists of ten items that measure both positive and negative feelings about the self. In our sample, Cronbach's Alpha of RSES at pre-test and post-test were, respectively 0.91 and 0.92.

Procedure

Each participant filled in a consent form before the experiment. All participants were tested individually. The experiment began with pre-test assessments. Participants completed the Drive for Thinness and Body Dissatisfaction subscales of the EDI-2, the CDRS, the CESD and the RSES. Participants were then randomly assigned to one of the experimental conditions. The experimenter took the three photographs used as CSs directly within the EC app installed on an iPod Touch that was lent to the participant. The experiment was presented as dealing with the relationship between emotional state and performance in a self-related visual memory game (no reference to body dissatisfaction or eating behavior was included in the presentation of the study). Participants were asked to fulfill at least one game session a day for the next 7 days and the date for the post-test was scheduled about a week later. At post-test, participants completed the same evaluations as at pre-test in addition to the Bulimia subscale of the EDI-2 and the Restraint subscale of the EDE-Q.

RESULTS

Analytic Plan

In order to ascertain the absence of differences between the two groups before the intervention, pre-test ratings of all measurements were subjected to independent-sample comparison. Then, for each participant, we computed five *evolution scores* corresponding to the difference between post-test and pre-test scores for the Drive for Thinness and Body Dissatisfaction subscales of the EDI-2, the CDRS, the CESD and the RSES. Negative differences corresponded to a reduction of the score from pre-test to post-test (see **Table 1**). These evolution scores, as well as the scores for the Bulimia subscale of the EDI-2 and the Restraint subscale of the EDE-Q (only assessed at post-test) and data from the app (e.g., number of sessions, number of correct responses) were analyzed using independent-sample comparison. Finally, evolution scores were analyzed to determine if they were significantly different from absence of evolution. In other words, we determined whether or not the differences between scores at pre-test and at post-test were statistically significant.

Because normality of distribution was not respected, we used a non-parametric Mann-Whitney U test and a One-Sample Wilcoxon Median test as independent-sample comparison and one-sample comparison tests (comparison value = 0). No participants were excluded or dropped out, and there were no missing data.

Pre-test Analysis and Application Check

Analysis of pre-test evaluations revealed no significant difference between the two conditions. In other words, Age ($U = 422.5$; $p > 0.05$), BMI ($U = 460.00$; $p > 0.05$), Drive for Thinness ($U = 435.5$; $p > 0.05$), and Body Dissatisfaction ($U = 450.5$; $p > 0.05$) subscales of the EDI-2, the CDRS ($U = 493.5$; $p > 0.05$), the CESD($U = 498.5$; $p > 0.05$) and the RSES [$t(58) = 0.927$; $p. > 0.05$] were not different in the two conditions before the experimental manipulation.

On average, participants kept the app 10.00(5.38) days and completed 10.20(4.74) sessions during this period with an average of 55.81(3.07) correct responses (over 60 trials) per session. No difference between the two groups was observed on these variables (respectively, $U = 371.5$; $p > 0.05$; $U = 520$; $p > 0.05$; $p > 0.05$; $U = 561.5$; $p > 0.05$).

Effect of Intervention

Independent comparison of evolution scores for body dissatisfaction revealed that participants in the EC condition did not elicit a stronger reduction in body dissatisfaction ($M = -0.97$) than participants in the neutral condition ($M = -1.87$; $U = 427.5$; $p > 0.05$) (**Table 1**). However, evolution of scores from pre to post-test, collapsed across conditions, revealed a reduction in body dissatisfaction. Indeed, participants elicited an evolution score significantly different from 0 ($W = 419$; $p < 0.05$) with a small effect size ($r = 0.27$) corresponding to a significant decrease in the body dissatisfaction score from pre-test to post-test independently of the condition.

Analysis of drive for thinness revealed the same pattern of results. Participants in the EC condition did not elicit a stronger reduction in drive for thinness ($M = -3.57$) than participants in the neutral condition ($M = -3.43$; $U = 469.5$; $p > 0.05$). However, overall, participants elicited an evolution score significantly different from 0 ($W = 132.5$; $p < 0.001$) with a large effect size ($r = 0.67$). In other words, all participants manifested a significant decrease in the drive for thinness score from pre-test to post-test, but this difference was not larger in the EC condition.

Analysis of self-esteem revealed the same pattern of results. Participants in the EC condition did not elicit a stronger augmentation in self-esteem ($M = 0.60$) than participants in the neutral condition ($M = -0.53$; $U = 401$; $p > 0.05$). However, overall, participants elicited an evolution score significantly different from 0 ($W = 968$; $p < 0.05$) with a small effect size ($r = 0.29$). In other words, all participants manifested a significant increase in self-esteem score from pre-test to post-test, but this difference was not larger in the EC condition.

TABLE 1 | Mean scores as function of condition and assessment time.

	Pre-test assessment		Post-test assessment		Evolution score pre/post-test	
	EC condition M (SD)	Neutral condition M (SD)	EC condition M (SD)	Neutral condition M (SD)	EC condition M (SD)	Neutral condition M (SD)
DT	22.80 (5.31)	22.43 (7.45)	19.23 (5.90)	19.00 (6.79)	−3.57 (4.75)	−3.43 (4.14)
BD	33.67 (8.87)	33.43 (10.98)	32.70 (9.32)	33.43 (10.98)	−0.97 (4.26)	−1.87 (6.56)
CDRS	−1.77 (1.36)	−1.43 (1.65)	−1.57 (1.28)	−1.30 (1.62)	−0.30 (1.12)	−0.13 (0.57)
CES-D	17.23 (9.48)	19.70 (11.54)	16.63 (11.94)	18.33 (11.17)	−0.60 (9.02)	−1.37 (7.97)
RSES	29.13 (5.42)	27.70 (6.51)	29.73 (5.49)	28.23 (6.66)	0.60 (4.19)	0.53 (2.06)
Bulimia	–	–	10.60 (4.77)	10.43 (3.27)	–	–
Restraint	–	–	7.47 (6.43)	7.70 (7.64)	–	–

DT (drive for thinness), BD (body dissatisfaction), and Bulimia are three subscales of the Eating Disorder Inventory. CDRS = contour drawing rating scale. CES-D = center for epidemiologic studies depression. RSES = rosenberg self-esteem scale (RSES). Restraint is a subscale of the Eating Disorder Examination Questionnaire.

Analysis of other scores revealed no effect regarding any other variables. Evolution scores for depressive symptoms (CES-D) and body size dissatisfaction (CDRS) where not different for the two conditions (respectively, $U = 470.5$; $p > 0.05$ and $U = 429$; $p > 0.05$). Moreover, these evolution scores were not significantly different from 0 (respectively, $W = 574$; $p > 0.05$ and $W = 192$; $p > 0.05$). Finally, bulimia and restraint scores were not different in the two conditions at the end of the experiment (respectively, $U = 463$; $p > 0.05$ and $U = 477.5$; $p > 0.05$). All data for this article can be found online (see **Supplementary Table S1**).

DISCUSSION

This study was designed to test the possibility of decreasing body dissatisfaction using EC within an app-based intervention. Participants used a brief EC game-like app during a week. Like Martijn et al. (2010) and Aspen et al. (2015) we observed a significant decrease in body dissatisfaction and an increase in self-esteem after the intervention. We also observed a decrease in drive for thinness. However, contrary to our hypothesis, these effects were not larger for the EC condition than for the neutral condition. This will be discussed. To the best of our knowledge, this is the first study to evaluate the effects of an app-based EC intervention targeting body image.

The current methodology was specifically developed to maximize the chances of obtaining an EC effect. The rules of each EC session requiring the participant to memorize pairs aimed to facilitate contingency awareness which has been found to be the most potent moderator of the EC effect (Hofmann et al., 2010).

In previous research observing an effect of an EC procedure, pictures of the participant's body were followed by smiling faces (100%), while pictures of control bodies were followed by neutral (50%) or frowning faces (50%). These studies did not determine whether learning the *participant-positive* association, the *other-negative* association, or both together drove the effects. The *other-negative* association could in itself explain the effects observed. Indeed, Martijn et al. (2013) observed that when participants learned to associate pictures of others bodies (thin-ideal models) with negative stimuli, participants elicited an increase in body satisfaction scores. In the present research, no pictures of other people's bodies were presented. Participants only learned to associate images of their own body with USs.

Given these precautions, our hypothesis was that any changes in body image related outcomes observed in participants in the EC condition would be driven by an EC effect relying on an association of images of the participants' own bodies and USs. Participants would have learned to associate their own body with positive USs and elicited a reduction in body dissatisfaction. However, because the effects observed in the EC condition were not significantly different to those observed in the neutral condition, we cannot affirm that the EC effect was responsible for these outcomes.

The efficacy of the neutral condition could be explained by the exposure effect. In cognitive behavior therapy, exposure exercises usually require exposing participants to their own body (e.g., mirror exposure), in order to gradually extinguish negative responses to these stimuli. Body exposure has been shown to reduce body dissatisfaction as well as weight and shape concerns in women (Delinsky and Wilson, 2006). In the neutral condition, during each session, participants were exposed to images of their own body 60 times a day. The absence of superiority of the EC condition in the present study does not support the use of EC in its present form as a better intervention than mirror (or app-based) exposure in university women. Note that in Martijn et al. (2010), Aspen et al. (2015), and Glashouwer et al. (2019), the control condition consisted of randomly associating the participant's body and other bodies with positive, neutral and negative stimuli which does not support the exposure explanation.

The present research does provide some contributions. The present study found that EC training could be implemented outside of the laboratory. Together with Kollei et al. (2017), our findings suggest that an app-based intervention may significantly reduce body dissatisfaction even if the present study did not support the idea that the EC effect was responsible for this change. Furthermore, previous research finding an influence of an EC procedure on body satisfaction only used standardized material (standard fitted black clothes). Here, we observed a decrease in body dissatisfaction with unstandardized photographs of participants wearing their own clothes. Given these points and that participants were not selected based on body concern, it is easy to imagine the implementation of this intervention as a real-life prevention program in a non-clinical population. Moreover, game-like methodologies (or gamification) facilitate the enjoyment and engagement of participants (Looyestyn et al., 2017), and should be encouraged in the development of mental health interventions.

While changes in body dissatisfaction, drive for thinness and self-esteem were observed, we found no evidence for a change of other measured outcomes (eating behaviors and depressive symptoms). These null-results could be explained by the nature of our population. Indeed, the only proof of the influence of an EC procedure on eating behavior was observed by Aspen et al. (2015) who only recruited participants considered at high risk for developing an eating disorder. Here, we did not recruit an at risk population, but typical university women. This could have resulted in a floor effect in relation to problematic eating behaviors. Finally, while depressive symptoms were not measured in previous studies, the same rationale could apply. Indeed, with the CES-D, the optimal cutoff for women was determined to be 23 (Henry et al., 2018), while in our sample, the mean score at pre-test assessment was 18,46. Thus, depressive symptoms could have been too low to be influenced by our method.

A number of limitations need to be considered when interpreting the present findings. As most previous studies, the present study was based on a sample composed of undergraduate women. Hence, the generalizability of the findings is limited. The absence of a control condition, without any task, or without exposure to photographs of the participant's own body does not allow us to conclude with certainty regarding the reasons for the efficacy of the neutral condition. The present results are only based on self-report assessments which does not protect from a demand effect. Finally, despite our efforts in selecting USs, we can't exclude the possibility that a social comparison effect occurred.

App based designs appear to be promising and could easily be implemented in the everyday world as they constitute low effort, attractive and accessible interventions. However, the present findings do not support the idea that EC is responsible for the observed effects which could be explained by the exposure effect. Future research should explore the effects of interventions on automatic evaluations and de-ambiguate the mechanisms involved.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this manuscript are available through doi: 10.6084/m9.figshare.8943302.v1.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Comité d'Éthique pour la Recherche, Université de Lille (2017-01-57) https://www.univ-lille.fr/recherche/la-recherche-au-service-de-la-societe/ethiques/. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

TK designed the study, performed the experiments, analyzed the data, and wrote the manuscript.

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REFERENCES

Aspen, V., Martijn, C., Alleva, J. M., Nagel, J., Perret, C., Purvis, C., et al. (2015). Decreasing body dissatisfaction using a brief conditioning intervention. *Behav. Res. Ther.* 69, 93–99. doi: 10.1016/j.brat.2015.04.003

Bouvard, M., Denis, A., and Roulin, J. L. (2013). Confirmation of the dimensions of the french version of the self-assessment scale of the center for epidemiological studies-depression (CES-D). *L'Encephale* 39, 452–453. doi: 10.1016/j.encep.2012.01.006

Criquillon-Doublet, S., Divac, S., Dardenne, R., and Guelfi, J. D. (1995). "Le Eating Disorder Inventory," in *Psychopathologie Quantitative*, eds J. D. Guelfi, V. Gallac, and R. Dardenne, (Paris: Masson), 249–260.

De Houwer, J. (2007). A conceptual and theoretical analysis of evaluative conditioning. *Span. J. Psychol.* 10, 230–241. doi: 10.1017/S1138741600006491

Delinsky, S. S., and Wilson, G. T. (2006). Mirror exposure for the treatment of body image disturbance. *Int. J. Eat. Disord.* 39, 108–116. doi: 10.1002/eat.20207

Etu, S. F., and Gray, J. J. (2010). A preliminary investigation of the relationship between induced rumination and state body image dissatisfaction and anxiety. *Body Image* 7, 82–85. doi: 10.1016/j.bodyim.2009.09.004

Fairburn, C. G., and Beglin, S. J. (1994). Assessment of eating disorders: interview or self-report questionnaire? *Int. J. Eat. Disord.* 16, 363–370.

Franklin, J. C., Fox, K. R., Franklin, C. R., Kleiman, E. M., Ribeiro, J. D., Jaroszewski, A. C., et al. (2016). A brief mobile app reduces nonsuicidal and suicidal self-injury: evidence from three randomized controlled trials. *J. Consult. Clin. Psychol.* 84:544. doi: 10.1037/ccp0000093

Garner, D. M. (1991). *Eating Disorder Inventory 2 Professional Manual*. Odessa, FL: Psychological Assessment Resources, Inc.

Garner, D. M. (2002). "Body image and anorexia nervosa," in *Body Image: A Handbook of Theory, Research, and Clinical Practice*, eds T. F. Cash, and T. Pruzinsky, (New-York, NY: Guilford).

Gast, A., Gawronski, B., and De Houwer, J. (2012). Evaluative conditioning: recent developments and future directions. *Learn. Motiv.* 43, 79–88. doi: 10.1016/j.lmot.2012.06.004

Glashouwer, K. A., Masselman, I., and de Jong, P. J. (2019). Reducing body dissatisfaction by means of an evaluative conditioning procedure in undergraduate women: a replication study. *Behav. Res. Ther.* 121:103435. doi: 10.1016/j.brat.2019.103435

Glashouwer, K. A., Neimeijer, R. A., de Koning, M. L., Vestjens, M., and Martijn, C. (2018). Evaluative conditioning as a body image intervention for adolescents with eating disorders. *J. Consult. Clin. Psychol.* 86:1046. doi: 10.1037/ccp0000311

Henry, S. K., Grant, M. M., and Cropsey, K. L. (2018). Determining the optimal clinical cutoff on the CES-D for depression in a community corrections sample. *J. Affect. Disord.* 234, 270–275. doi: 10.1016/j.jad.2018.02.071

Hermans, D., Vansteenwegen, D., Crombez, G., Baeyens, F., and Eelen, P. (2002). Expectancy-learning and evaluative learning in human classical conditioning: affective priming as an indirect and unobtrusive measure of conditioned stimulus valence. *Behav. Res. Ther.* 40, 217–234. doi: 10.1016/S0005-7967(01)00006-7

Hofmann, W., De Houwer, J., Perugini, M., Baeyens, F., and Crombez, G. (2010). Evaluative conditioning in humans: a meta-analysis. *Psychol. Bull.* 136:390. doi: 10.1037/a0018916

Jansen, A., Bollen, D., Tuschen-Caffier, B., Roefs, A., Tanghe, A., and Braet, C. (2008). Mirror exposure reduces body dissatisfaction and anxiety in obese adolescents: a pilot study. *Appetite* 51, 214–217. doi: 10.1016/j.appet.2008.01.011

Kollei, I., Lukas, C. A., Loeber, S., and Berking, M. (2017). An app-based blended intervention to reduce body dissatisfaction: a randomized controlled pilot study. *J. Consult. Clin. Psychol.* 85:1104. doi: 10.1037/ccp0000246

Littleton, H. L., and Ollendick, T. (2003). Negative body image and disordered eating behavior in children and adolescents: what places youth at risk and how can these problems be prevented? *Clin. Child Fam. Psychol. Rev.* 6, 51–66. doi: 10.1023/A:1022266017046

Looyestyn, J., Kernot, J., Boshoff, K., Ryan, J., Edney, S., and Maher, C. (2017). Does gamification increase engagement with online programs? A systematic review. *PLoS One* 12:e0173403. doi: 10.1371/journal.pone.0173403

Maraldo, T. M., Zhou, W., Dowling, J., and Vander Wal, J. S. (2016). Replication and extension of the dual pathway model of disordered eating: the role of fear of negative evaluation, suggestibility, rumination, and self-compassion. *Eat. Behav.* 23, 187–194. doi: 10.1016/j.eatbeh.2016.10.008

Martijn, C., Sheeran, P., Wesseldijk, L. W., Merrick, H., Webb, T. L., Roefs, A., et al. (2013). Evaluative conditioning makes slim models less desirable as standards for comparison and increases body satisfaction. *Health Psychol.* 32:433. doi: 10.1037/a0028592

Martijn, C., Vanderlinden, M., Roefs, A., Huijding, J., and Jansen, A. (2010). Increasing body satisfaction of body concerned women through evaluative conditioning using social stimuli. *Health Psychol.* 29, 514–520. doi: 10.1037/a0020770

Myers, T. A., and Crowther, J. H. (2007). Sociocultural pressures, thin-ideal internalization, self-objectification, and body dissatisfaction: could feminist beliefs be a moderating factor? *Body Image* 4, 296–308. doi: 10.1016/j.bodyim.2007.04.001

Radloff, L. S. (1977). The CES-D scale: a self-report depression scale for research in the general population. *Appl. Psychol. Measur.* 1, 385–401. doi: 10.1177/014662167700100306

Rosenberg, M. (1965). Rosenberg self-esteem scale (RSE). Acceptance and commitment therapy. *Measur. Pack.* 61:52. doi: 10.1037/t01038-000

Stice, E., Marti, C. N., and Durant, S. (2011). Risk factors for onset of eating disorders: evidence of multiple risk pathways from an 8-year prospective study. *Behav. Res. Ther.* 49, 622–627. doi: 10.1016/j.brat.2011.06.009

Thompson, J. K., and Heinberg, L. J. (1999). The media's influence on body image disturbance and eating disorders: we've reviled them, now can we rehabilitate them? *J. Soc. Issues* 55, 339–353. doi: 10.1111/0022-4537.00119

Thompson, M. A., and Gray, J. J. (1995). Development and validation of a new body-image assessment scale. *J. Pers. Assess.* 64, 258–269. doi: 10.1207/s15327752jpa6402-6

Tiggemann, M., and McGill, B. (2004). The role of social comparison in the effect of magazine advertisements on women's mood and body dissatisfaction. *J. Soc. Clin. Psychol.* 23, 23–44. doi:10.1521/jscp.23.1.23.26991

Vallieres, E. F., and Vallerand, R. J. (1990). Traduction et validation canadienne-française de l'échelle de l'estime de soi de rosenberg. *Int. J. Psychol.* 25, 305–316. doi: 10.1080/00207599008247865

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Body Inversion Effects With Photographic Images of Body Postures: Is It About Faces?

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As with faces, participants are better at discriminating upright bodies than inverted bodies. This inversion effect is reliable for whole figures, namely, bodies with heads, but it is less reliable for headless bodies. This suggests that removal of the head disrupts typical processing of human figures, and raises questions about the role of faces in efficient body discrimination. In most studies, faces are occluded, but the aim here was to exclude faces in a more ecologically valid way by presenting photographic images of human figures from behind (about-facing), as well as measuring gaze to different parts of the figures. Participants determined whether pairs of sequentially presented body postures were the same or different for whole and headless figures. Presenting about-facing figures (heads seen from behind) and forward-facing figures with faces enabled a comparison of the effect of the presence or absence of faces. Replicating previous findings, there were inversion effects for forward-facing whole figures, but less reliable effects for headless images. There were also inversion effects for about-facing whole figures, but not about-facing headless figures. Accuracy was higher in the forward- compared to the about-facing conditions, but proportional dwell time was greater to bodies in about-facing images. Likewise, despite better discrimination of forward-facing upright compared to inverted whole figures, participants focused more on the heads and less on the bodies in upright compared to inverted images. However, there was no clear relationship between performance and dwell time proportions to heads. Body inversion effects (BIEs) were found with about-facing whole figures and headless forward-facing figures, despite the absence of faces. With inverted whole figures, there was a significant relationship between performance and greater looking at bodies, and less at heads suggesting that in more difficult conditions a focus on bodies is associated with better discrimination. Overall, the findings suggest that the visual system has greater sensitivity to bodies in their most experienced form, which is typically upright and with a head. Otherwise, the more a face is implied by the context, as in whole figures or forward- rather than about-facing headless bodies, the better the performance as holistic/configural processing is likely stronger.

Keywords: body representations, inversion effects, eye tracking, faces, headless bodies

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INTRODUCTION

Inverted faces are more difficult to discriminate than upright faces, and this inversion effect is larger than that seen with other objects such as dogs or houses (e.g., Diamond and Carey, 1986; Farah et al., 1995; Rossion, 2008). Explanations for the effect vary. One argument is that faces are a unique category subject to specialized processing, perhaps because we are highly familiar with them, and they share the same first-order configuration (eyes above nose above mouth), which means that telling them apart is based not just on the presence of certain features, but also holistic or configural processing (e.g., Robbins and McKone, 2007). Another category associated with equally large inversion effects is human bodies (e.g., Robbins and Coltheart, 2012b). Like faces, exposure to bodies is highly frequent, and they also share a first-order configuration (head on body, typically two arms on the sides, and two legs below). However, bodies are attached to faces, so one question is whether or how much the body inversion effect (BIE) is influenced by actual or induced face information when discriminating bodies.

Reed et al. (2003, 2006) were the first to report a BIE. Participants discriminated sequentially presented pairs of 3D software-created images of body postures (i.e., not natural bodies). For half of the pairs, the arm, leg, and head positions differed slightly and participants judged whether the pairs were the same or different. Participants were slower and less accurate for inverted compared to upright postures and the inversion effect was similar in magnitude to that seen on a facial identity task. Multiple studies have replicated Reed et al.'s (2003, 2006) findings with similar stimuli (Brandman and Yovel, 2010; Yovel et al., 2010, Experiment 1). BIEs have also been found in body identity discrimination tasks using photographic images, such that people were more accurate (Robbins and Coltheart, 2012b) and more efficient (inverse efficiency = RT/accuracy; Minnebusch et al., 2009) when discriminating upright compared to inverted images of people.

Perhaps surprisingly, early studies found no BIE for bodies WITHOUT heads (headless bodies). In an identity discrimination task, Minnebusch et al. (2009) found no inversion effect with upright and inverted headless bodies in accuracy or reaction time (RT), and a reversed BIE in efficiency such that participants were more efficient at discriminating *inverted* headless bodies than upright. Similarly, Yovel et al. (2010, Experiment 2) failed to find a BIE for posture discrimination with headless bodies for either accuracy (d') or RT (see also behavioral data in Brandman and Yovel, 2010, 2012). They further tested whether the BIE would be reduced when *any* body part is removed, not just the head, as we typically see human figures in their complete form. Figures presented without arms or missing a leg still led to BIEs. When the heads on the pairs of figures in the sequential matching tasks were in identical as opposed to variable positions, the BIE was reduced in magnitude suggesting that head positions contribute to the discriminatory process. Therefore, the failure to find a BIE was not due to the figures appearing in an incomplete form, but rather due to the absence of heads. Yovel et al. (2010) argued that the BIE was based on the presence of a head, such that it could be explained by the body activating face sensitive areas in the brain associated with a face inversion effect (FIE).

Brandman and Yovel (2012) further investigated the importance of a face to the BIE by presenting whole figures of people from behind (i.e., about-facing) again in a posture task. For these about-facing whole figures, a BIE was found, but it was significantly smaller in magnitude to that seen with forward-facing (faceless) whole figures. This study replicated a failure to find a BIE for forward-facing headless bodies. They also found FIEs for faceless heads, and faceless heads presented with upper torsos. Interestingly, following brief presentations of upright figures (27 milliseconds), participants were more likely to rate themselves as having *seen* a face in the faceless, forward-facing whole figures than in the headless figures, and they were least likely to rate themselves as having perceived a face in the about-facing whole figures. Brandman and Yovel (2010) argued that the more likely a face is induced by the contextual information in the stimuli, the more likely an inversion effect is found. However, it is somewhat surprising that a BIE is found with about-facing whole figures raising questions about the role of the implied existence of facial features in contributing to a BIE. Note, about-facing headless bodies were not presented presumably due to a lack of a BIE with forward-facing headless bodies. Including a headless about-facing condition would further test if induced facial information is key for a BIE.

Finally, in an fMRI paradigm, Brandman and Yovel (2010) measured differences in activation to pairs of different and same body postures in face-selective areas [fusiform face area (FFA) and occipital face area (OFA)] and body selective areas of the brain [extrastriate body area (EBA) and fusiform body area (FBA)]. A greater response to the different compared to the same posture pairs is suggestive of greater sensitivity. Brandman and Yovel (2010) found that face selective areas were only sensitive to (faceless) whole figures, but not headless bodies; whereas body-selective areas were sensitive to the presentations of whole figures and headless bodies in both upright and inverted orientations. In particular, the face-selective areas only demonstrated sensitivity to the upright, but not the inverted whole figures. Brandman and Yovel (2010) argued that this pattern of brain activation could explain why information from heads is critical to the BIE. Note, however, as about-facing whole figures were not presented in this study, it is uncertain as to whether face-selective areas are also sensitive to upright, about-facing whole figures.

However, the story for headless bodies is more complicated than these early studies imply. In an identity discrimination task, Robbins and Coltheart (2012b) found a significant BIE for headless bodies in accuracy in two experiments, although the inversion effect for headless bodies was smaller than for whole figures for unfamiliar bodies. More recently, Arizpe et al. (2017), using Yovel et al.'s (2010) stimuli, found a BIE with headless stimuli (with d'), but performance was weaker than that seen with whole figures and the inversion effect for whole and headless bodies in RT was similar, and both significant.

How can Yovel et al.'s (2010) and Brandman and Yovel's (2010, 2012) findings be reconciled with Arizpe et al. (2017) who found a headless body posture BIE, and Robbins and Coltheart (2012b) who found a headless body identity BIE, or even

Minnebusch et al.'s (2009) reversed headless BIE? Yovel et al.'s (2010) failure to find a headless BIE could be due to reduced statistical power to find a real but small effect, as they had only $n = 12$ per condition. Brandman and Yovel (2012) had slightly more participants with $n = 14$ per condition. Arizpe et al. (2017) had a slightly larger sample of $n = 16$, but still found weaker performance than that seen with whole figures. Minnebusch et al. (2009) found no or a reversed BIE for headless bodies, depending on the dependent variable, with $n = 17$. Robbins and Coltheart (2012b) had $n = 24$ in their familiarized bodies experiment (Experiment 1) and $n = 40$ in their unfamiliar bodies experiment (Experiment 2). Susilo et al. (2013) found BIEs with whole and headless bodies, also with Yovel et al.'s (2010) stimuli, in a small sample of participants (3 out of 4) with acquired prosopagnosia (condition involving a difficulty in recognizing faces). In a follow-up study, Quigan et al. (in preparation) found a BIE for whole figure and headless bodies with an even larger sample size amongst participants with ($n = 70+$) and without developmental prosopagnosia ($n = 70+$). Effect sizes in Yovel et al. (2010; Cohen's d) ranged from 1.7 for armless to 4.5 for whole figures with varied heads, but the key effect size for headless bodies is not provided. The other studies cited here did not provide effect sizes. It does seem, however, that when the sample sizes were larger, a headless BIE is found (Robbins and Coltheart, 2012b; Arizpe et al., 2017; Quigan et al., in preparation). The current study had $n = 28$ in each condition to ensure that any null results for headless bodies would be more reliable.

Another question about Yovel et al.'s (2010) and Brandman and Yovel's (2010, 2012) studies is that the stimuli were not real, but instead 3D-software created bodies. Observers might be more willing to suspend their disbelief at the sight of a headless or an inverted body. This cannot be the only reason that Yovel et al. (2010) did not find a BIE for headless bodies, as Arizpe et al. (2017) found a BIE with the same stimuli, and Minnebusch et al. (2009) did not find a BIE with photographs of real people. However, one issue with Minnebusch et al.'s (2009) stimuli is that the test pairs were not matched in clothes and hair and responses could have been based more on these differences than on identity information. Further, in Brandman and Yovel's (2012) study, examining whether an implied face leads to a BIE, they presented whole figures with faces occluded, headless bodies (forward-facing) and whole figures from behind (about-facing). This did not allow a direct comparison of whole figures WITH faces to whole figures without a face or forward- and about-facing headless bodies. By presenting people from behind, a face is less expected, as was found by Brandman and Yovel (2012) with about-facing whole figures. However, they still found a BIE with about-facing whole figures. Perhaps the presence of a head, albeit from behind, still induces an implied presence of a face, which in turn contributes to a BIE. Bodies are also seen with heads suggesting that whole figure inversion effects could also be partly explained by experience. The current study thus used photographs of real people seen from the front and behind (forward- and about-facing), in both whole figures and headless versions to allow direct comparisons of responses to images with and without faces that were also with and without heads.

The current study used a posture discrimination task using sequential matching, and given the previous findings (Reed et al., 2006; Brandman and Yovel, 2010, 2012; Yovel et al., 2010; Arizpe et al., 2017), a BIE was expected with forward-facing whole figures. Including about-facing whole figures might more directly address the role of faceless figures in a more ecologically valid way, one that does not involve occluding facial features. Aside from Brandman and Yovel (2012), there are no other known studies involving about-facing images; and no known studies presenting about-facing headless stimuli. If Yovel et al. (2010) are correct, and the BIE for whole figures is based on an induced face, then we expected a BIE for the about-facing whole figures given the presence of a head. Given the inconsistent findings in previous studies (e.g., Yovel et al., 2010; Arizpe et al., 2017) it was uncertain as to whether BIEs would be seen with headless images and if the effects would vary for forward- and about-facing images. Given that participants in Brandman and Yovel (2010) were less likely to rate themselves as having seen a face in both the (forward-facing) headless and about-facing whole figures, it would be highly unlikely that a face is perceived in headless about-facing images. If the BIE is based on the induced presence of a face a smaller or no BIE was expected for the headless stimuli, in particular the about-facing headless stimuli. However, a BIE for forward-facing headless stimuli was also considered possible given that Brandman and Yovel (2010) found that participants still perceived faces in these images (albeit weakly) and others have found a BIE with forward-facing headless stimuli (e.g., Arizpe et al., 2017).

We also measured where people looked for whole versus headless, front- versus about-facing figures, and upright versus inverted images. Arizpe et al. (2017) found that participants tended to look longer at the upper regions of the upright whole figures such that they looked longer at the upper torso and heads, and for inverted figures they looked longer at the lower torso. When instructed to look at the heads or the upper torso of figures in both orientations, performance was better than when looking at the lower portions of the figures. All of Arizpe et al.'s (2017) images were forward-facing with faces occluded. We compared how much participants focused on heads in forward-facing images (with faces) and about-facing images (without faces), and how much people focus on bodies given that it was a body discrimination task in images with matching heads. Looking times to feet were analyzed as the feet in the inverted images appear in the upper region of the screen. The feet are part of the body posture and one question was whether a focus on this upper region of inverted images contributes to performance in the inverted conditions.

MATERIALS AND METHODS

Participants

Participants took part in either the about-facing or the forward-facing condition. A power analysis based on the effect size $\eta_p^2 = 0.33$ found by Yovel et al. (2010) suggested a suitable sample size of 28 ($\alpha = 0.05$, $\beta = 0.95$) for each condition (about- and forward-facing). The participants were recruited via the Australian National University (ANU) research participation sign-up webpage (SONA) and by word-of-mouth. In the about-facing experiment (n = 28), the mean age was 22.34 years (SD = 3.96 years, range = 18 to 34 years; 22 female, 6 male, 0 other), and 19 were Caucasian, 8 Asian, and 1 African. A further three people participated, but their data were excluded due to difficulties with eye tracking (n = 2) and sleepiness (n = 1). In the forward-facing experiment (n = 28), the participants had a mean age of 20.33 years (SD = 2.34 years, range = 18 to 30 years; 16 female, 12 male, 0 other), and 18 were Caucasian, and 10 Asian. A further five participated, but their data were excluded due to technical problems (n = 1) and difficulties with concentration and engagement with the task (n = 4). All participants had reported normal or corrected-to-normal vision and received course credit. The experiments were conducted in accordance with ethical standards and were approved by the ANU's Human Research Ethics Committee (Protocol number 2015/183).

Apparatus

An EyeLink 1000 (SR Research) eye tracker recorded participants' eye movements by recording the infrared reflections from the cornea and pupil with a sampling frequency of 1000 Hz, and average spatial accuracy of 0.15°. Using the Desktop Mount set-up, participants' heads were stabilized with a chin-rest positioned 90 cm from the display and 70 cm from the camera. The eye tracking camera was positioned directly in front of and beneath a 24-inch Dell Monitor with a resolution of 1920 × 1080 pixels, and 60 Hz refresh rate.

Stimuli

High quality photographs of 16 pairs of about-facing and 16 pairs of forward-facing adult, male figures were sourced from Shutterstock[1] (see **Figure 1**). This necessarily meant that the identities of the about- and forward-facing bodies were different and the poses were slightly different. Only male figures in similar clothing (jeans/trousers and t-shirt, long-sleeved shirt or jumper/sweater) were used to attempt to reduce attention to clothing. Importantly, each pair had the same clothing and differed only in posture (see **Figure 1**). All had short hair and similar body shapes with only mild variations in weight. Four versions of each pair were created using Adobe Photoshop (CS6), one for each condition: whole figure upright (WFU), whole figure inverted (WFI), headless upright (HLU), and headless inverted (HLI) resulting in 64 stimuli pairs in each facing direction (about- or forward-facing, see **Figure 1**). Each pair of whole figure stimuli had an identical head; only the body postures differed. Headless stimuli were created by removing the head of the whole figure stimuli from the top of the upper garment of clothing (see **Figure 1**). Images were rotated 180° to create inverted stimuli. In the about-facing condition, all images were people photographed from behind. The average size of the whole figures was 8.44 × 12.84°, and the headless figures, 8.44° × 11.36° at a 90 cm distance. In the forward-facing condition, all images were photographs of people from a frontal view with faces visible in the whole figure conditions; and the average size of the whole figures was 7.33° × 13.11°, and the headless figures, 7.33° × 11.23° and the (see **Figure 1**). The postures were altered in 2D space by rotating or shifting the limbs of the figures up or down using Adobe Photoshop (CS6). They were divided into three categories based on the type of change made to create different postures. In each facing direction (about- and forward-facing), six pairs had a leg and an arm rotated, five pairs had only a leg rotated, and five pairs had only an arm rotated. All poses were deemed biologically possible by authors ELA and HFC. The degree of limb rotation performed in Photoshop between the initial image and the test image of each pair was 10°–15° in the "leg and arm" category, and 20°–30° in both the "arm-only" and "leg-only" categories. A smaller degree of limb rotation was used in the "leg and arm" category as the difference in postures were in two limbs, as opposed to one limb in the other categories. Head positions were identical between the pairs.

[1] www.shutterstock.com

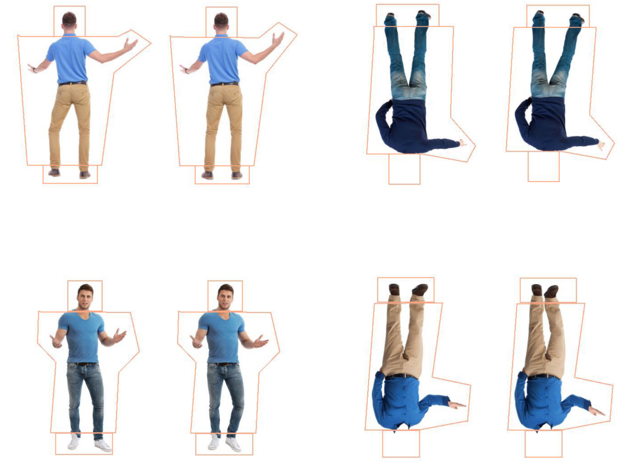

FIGURE 1 | About-facing whole figure upright (WFU) and headless inverted (HLI) stimuli (top) and forward-facing WFU and HLI stimuli (bottom) with interest areas (IAs) surrounding the heads, bodies, and feet.

Procedure and Design

Participants' fixations were calibrated and validated using the standard EyeLink 1000 nine-point display. The experiment commenced once validation values of the calibration points were less than 1° visual angle. The experimenter provided instructions (orally) and written instructions also appeared on the display monitor prior to eight practice trials. The practice stimuli did not appear in the main experiment. Each trial began with a "drift correct" calibration point presented in the center of the display to ensure the participants' fixations remained calibrated throughout. Using a sequential matching method, participants saw an initial posture from a given pair for 250 ms, followed by a 1000 ms inter-stimulus interval (ISI, a blank white screen). The test image appeared and remained on the screen until participants indicated using a keyboard if the body posture was the same or different as the initial image. Velcro was attached to two keys as tactile reminders of which keys corresponded with the "same" (smooth, "z" key) or "different" options (rough, forward slash key). Participants had 5000 ms to respond before the trial terminated and a "no-response" was recorded. Any "no-response" trials were excluded. In the forward- and about-facing conditions, respectively, participants saw all 64 pairs of stimuli, and each participant saw each image in a pair serve as the initial image or test image an equal number of times. Participants saw all four body type conditions (WFU, WFI, HLU, and HLI). There were four versions of the task which counterbalanced the order of presentation of the conditions. Trials were termed "same" or "different" depending on whether a change in body posture was present and each image appeared in an equal number of same or different trials. The same/different status of trials was randomized, as was which of the two images within each pair was presented first. A given pair appeared only once every eight trials to ensure the presentation of individual pairs was spread out. Participants took approximately 15 min to complete all trials.

RESULTS

Data was extracted using Data Viewer software version 1.10.1630 (SR Research). The data were analyzed using JASP 0.10.0.0. Both *d*' and inverse efficiency scores were the main dependent variables. Signal detection sensitivity (SDT, *d*', see Stanislaw and Todorov, 1999 for a review) was used to analyze accuracy in discriminating body postures as it incorporates correct and incorrect responses. More specifically, signal sensitivity (*d*') indicates the difference between each participant's standardized mean hit rate (proportion of correct responses in trials with "same" postures) and standardized mean false-alarm rate [proportion of incorrect responses in trials with "different" postures, $d' = z(\text{hit rate}) - z(\text{false alarm rate})$]. Larger *d*' scores indicate a stronger recognition of change in body signal, and consequently, better performance. Response bias (criterion *c*) is a measure of participants' tendency to be conservative and report no change (i.e., same) in body posture across both same and different trials. Efficiency was also analyzed to account for speed/accuracy trade-offs and was calculated by dividing the mean RTs in correct trials by the proportion of correct responses for each participant in each condition (Minnebusch et al., 2009; Bruyer and Brysbaert, 2011). To directly test for inversion effects, planned paired *t*-tests were also performed comparing performance between the upright and inverted images for each body type (for the whole figure and headless figures in the about- and forward-facing conditions).

d Prime

A 2 × 2 × 2 mixed model ANOVA comparing *d*' across the two facing directions (about-facing, forward-facing), the two body types (whole figure, headless), and the two orientations (upright, inverted) revealed that there was a main effect of facing direction, $F(1,54) = 19.76$, $p < 0.001$, $\eta_p^2 = 0.27$. Participants were overall more accurate in the forward-facing ($M = 1.58$, $SD = 0.94$) than in the about-facing condition ($M = 0.96$, $SD = 0.68$). The main effect of body type was non-significant, $F(1,54) = 0.09$, $p = 0.770$, $\eta_p^2 = 0.01$, but there was a significant main effect of orientation, $F(1,54) = 10.99$, $p = 0.002$, $\eta_p^2 = 0.17$. *d*' scores were overall higher in the upright ($M = 1.47$, $SD = 0.82$) compared to the inverted conditions ($M = 1.08$, $SD = 0.80$). The interaction between facing direction and body type was non-significant, $F(1,54) = 0.07$, $p = 0.937$, $\eta_p^2 < 0.01$, but the interaction between facing direction and orientation, $F(1,54) = 4.35$, $p = 0.042$, $\eta_p^2 = 0.07$, and the interaction between body type and orientation were significant, $F(1,54) = 4.85$, $p = 0.032$, $\eta_p^2 = 0.08$. The facing direction by body type by orientation interaction was non-significant, $F(1,54) = 0.73$, $p = 0.398$, $\eta_p^2 = 0.01$. These interactions are explained in the following *a priori t*-tests.

In the about-facing condition, participants were more accurate ($DV = d'$) at detecting changes in body posture in the WFU condition ($M = 1.15$, $SD = 0.71$) compared to the WFI condition ($M = 0.74$, $SD = 0.69$), $t(27) = -2.42$, $p = 0.023$, $d = -0.46$. There was no significant difference between the HLU ($M = 0.92$, $SD = 0.59$) and HLI conditions ($M = 1.04$, $SD = 0.73$), $t(27) = 0.78$, $p = 0.440$, $d = 0.15$. Therefore, for the about-facing images, there was a BIE in the whole figure, but not the headless conditions. The effect sizes also reflect this pattern with a small-to-medium effect size for the whole figure condition and a small effect size for headless. Difference scores were then calculated between the upright and inverted conditions for the whole figure and headless conditions. A comparison of the difference scores revealed that the magnitude of the difference between the upright and inverted images (i.e., the BIE) was significantly larger in the whole figure ($M = 0.41$, $SD = 0.89$) than in the headless conditions ($M = 0.11$, $SD = 0.82$), $t(27) = 3.86$, $p < 0.001$, Bonferroni-corrected[2] ($\alpha \times 2$) < 0.001, $d = 0.74$ (see **Figure 2**).

In the forward-facing condition, for the whole figure images, *d*' was higher in the WFU condition ($M = 1.95$, $SD = 0.99$) than in the WFI condition ($M = 1.20$, $SD = 0.92$), $t(27) = 3.19$, $p = 0.004$, $d = 0.60$. Interestingly, this was also the case for the headless images as *d*' was significantly higher in the HLU ($M = 1.85$, $SD = 0.99$) than in the HLI condition ($M = 1.33$, $SD = 0.85$), $t(27) = 2.07$, $p = 0.048$, $d = 0.39$. Therefore, for the forward-facing images, there was a BIE in the whole figure and the headless conditions. The effect size was medium for the whole figure condition and small for the headless condition. Comparing the difference scores between the upright and inverted conditions, revealed that the magnitude of the BIE did not differ significantly between the whole figure ($M = 0.75$, $SD = 1.24$) and the headless conditions ($M = 0.52$, $SD = 1.32$), $t(27) = 0.73$, $p = 0.471$, corrected ($\alpha \times 2$) = 0.942, $d = 0.14$ (see **Figure 2**).

Further, the magnitude of the inversion effect between the whole figure images in the about-facing and forward-facing conditions was non-significant, $t(54) = 1.18$, $p = 0.242$, corrected ($\alpha \times 4$) = 0.968, $d = 0.32$. For the headless images, the inversion effect between the about-facing and forward-facing conditions was also non-significant with a correction, $t(54) = 2.10$, $p = 0.040$, corrected ($\alpha \times 4$) = 0.160, $d = 0.57$ (see **Figure 2**). Interestingly, the effect sizes across the about-facing and forward-facing conditions were similar in that for both they were larger in the whole figure than in the headless conditions.

[2] All subsequent corrections are Bonferroni-corrected.

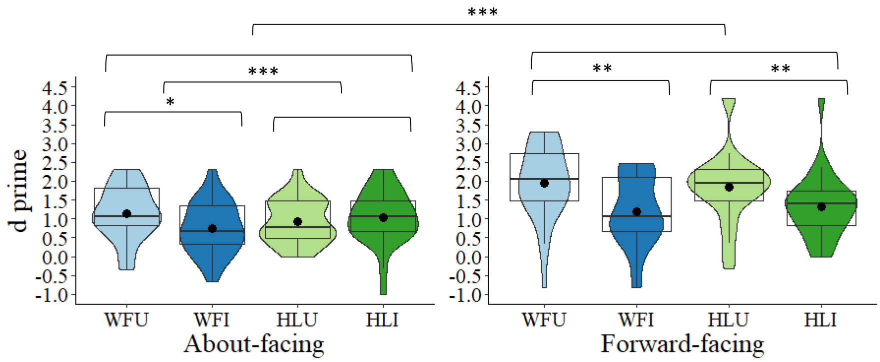

FIGURE 2 | Box and violin plots of *d'* scores for the four conditions: whole figure upright (WFU), whole figure inverted (WFI), headless upright (HLU), headless inverted (HLI) in the about-facing and forward-facing conditions; dots denote means; ***$p < 0.001$; **$p < 0.01$; and *$p < 0.05$.

Criterion *c* Response Bias

One participant in the about-facing condition had outliers in all four conditions (>2.5 *SD*s) and the scores were replaced with the condition means. Participants were overall more conservative (i.e., greater tendency to report no change or a "same" response in body posture across both same and different trials) in the about-facing than in the forward-facing condition. They were also overall more conservative in the inverted compared to the upright conditions. In the about-facing condition, participants were also significantly more conservative in the HLI than in the HLU condition (see **Supplementary Materials** for details).

Efficiency Scores

In the about-facing condition there were three outliers (*z*-score > 2.5 *SD*), one each in the WFI, HLU, and HLI conditions and these were replaced with the condition mean. A 2 × 2 × 2 mixed model ANOVA was performed to compare efficiency scores across the two facing directions (about-facing, forward-facing), between the two body types (whole figure, headless), and the two orientations (upright, inverted). The main effects of facing direction, $F(1,54) = 0.02$, $p = 0.904$, $\eta_p^2 \leq 0.01$, and body type, $F(1,54) = 1.80$, $p = 0.185$, $\eta_p^2 = 0.03$, were non-significant. The main effect of orientation was significant, $F(1,27) = 14.16$, $p \leq 0.001$, $\eta_p^2 = 0.21$, as scores were overall more efficient in the upright ($M = 1234.05$, $SD = 359.04$) compared to the inverted conditions ($M = 1392.49$, $SD = 464.91$). There was a non-significant trend for an interaction between body type and orientation, $F(1,54) = 3.84$, $p = 0.055$, $\eta_p^2 = 0.07$. The interactions between facing direction and body type, $F(1,54) = 0.48$, $p = 0.493$, $\eta_p^2 = 0.01$, facing direction and orientation, $F(1,54) = 0.65$, $p = 0.425$, $\eta_p^2 = 0.01$, and facing direction by body type by orientation, $F(1,27) = 0.05$, $p = 0.825$, $\eta_p^2 \leq 0.01$, were non-significant.

The main question was to determine whether there was a BIE for the different facing directions and body types, despite the non-significant interactions. In the about-facing condition, for the whole figure images, scores were significantly more efficient in the WFU condition ($M = 1222.35$, $SD = 299.50$) than in the WFI condition ($M = 1416.72$, $SD = 467.04$), $t(27) = -3.32$, $p = 0.003$, Cohen's $d = -0.63$. For the headless images, the difference between HLU ($M = 1268.59$, $SD = 320.59$) and HLI ($M = 1324.39$, $SD = 380.74$) was non-significant, $t(27) = -0.86$, $p = 0.397$, $d = -0.16$. Therefore, for the about-facing images, there was a BIE in the whole figure, but not the headless conditions, which is also reflected in the effect sizes, with a medium effect size in the whole figure condition and small in the headless condition. Differences scores were then calculated between the upright and inverted conditions. A comparison of the difference scores between the whole figure and headless conditions, revealed that the magnitude of the difference between the upright and inverted images (i.e., the BIE) was non-significant between the whole figure ($M = 193.37$, $SD = 308.40$) and the headless conditions ($M = 55.80$, $SD = 343.40$), when a correction was applied, $t(27) = 2.15$, $p = 0.041$, corrected ($\alpha \times 2$) = 0.082, $d = 0.41$ (see **Figure 3**).

In the forward-facing condition, participants were significantly more efficient in the WFU condition ($M = 1230.34$, $SD = 394.53$) than in the WFI condition ($M = 1477.41$, $SD = 546.96$), $t(27) = -3.07$, $p = 0.005$, $d = -0.58$; whereas for the headless images, the difference between HLU ($M = 1214.93$, $SD = 421.56$) and HLI ($M = 1352.46$, $SD = 431.15$) was non-significant, $t(27) = -1.53$, $p = 0.137$, $d = -0.29$. Therefore, for the forward-facing images, there was a BIE in the whole figure, but not the headless conditions. Similarly, the effect was medium in the whole figure condition and small in the headless condition. Based on the difference scores between the upright and inverted conditions, the magnitude of the difference between the upright and inverted images (i.e., the BIE) did not differ significantly between the whole figure ($M = 247.07$, $SD = 425.91$) headless conditions ($M = 137.53$, $SD = 474.69$), $t(27) = 1.01$, $p = 0.322$, corrected ($\alpha \times 2$) = 0.644, $d = 0.19$ (see **Figure 3**).

Further, the difference in the magnitude of the inversion effect between the whole figure images in the about-facing and forward-facing conditions was non-significant, $t(54) = 0.54$, $p = 0.591$, corrected ($\alpha \times 4$) = 1.00, $d = 0.14$. Likewise, for the headless images, the difference in the magnitude of the inversion effect between the about- and forward-facing conditions was non-significant, $t(54) = 0.74$, $p = 0.464$, corrected ($\alpha \times 4$) = 0.928, $d = 0.20$ (see **Figure 3**).

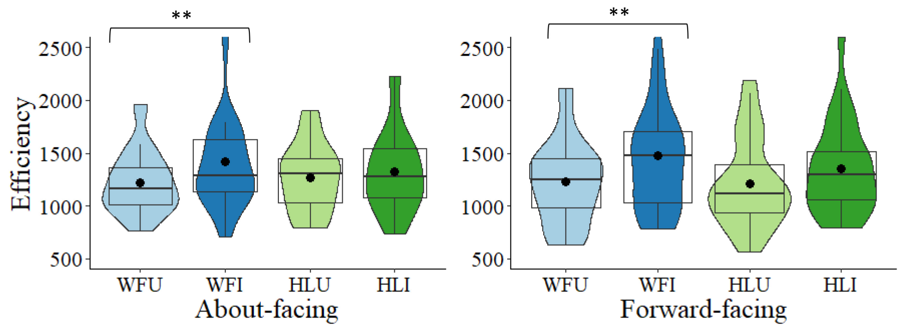

FIGURE 3 | Box and violin plots of efficiency scores for the four conditions: WFU, WFI, HLU, HLI in the about-facing and forward-facing conditions; dots denote means; ** $p < 0.01$.

Dwell Time to Heads, Bodies, and Feet

Polygonal interest areas (IAs) were created around the head, body, and feet of each image using Data Viewer software version 3.2.48 (SR Research). IAs were created around the feet because in the inverted images, the feet appear in the region where the head would normally appear. The IAs around the heads included the head and neck, the IAs around the bodies extended from the top of the torso to the ankles, and the feet IAs were around the feet of the figures. Given that there is a bias to look in the upper region (e.g., Arizpe et al., 2017), it was expected that participants might look to that region in the inverted condition. Dwell time (DT) refers to the summed durations of all the fixations within an IA. DT to the IAs of the test image was averaged across all trials in each condition. Proportional DTs to each IA (head, body, feet) were calculated by dividing looking to each IA by looking to all three IAs [e.g., DT to head/(head + body + feet)]. Proportional DT to the heads, bodies, and feet were compared separately across conditions to avoid violating the assumption of independence given that heads, bodies and feet appear simultaneously. Following this, for each figure type, the relationships between DT proportions to each IA and efficiency scores were analyzed to assess whether the proportion of time spent looking at particular areas was related to performance. Efficiency scores were used instead of *d'* because *d'* had restricted range making it less suitable for correlations.

Heads (Head and Neck)

As there was largely no looking at the head region of the headless stimuli, only the whole figure conditions were included in this analysis. A 2 × 2 mixed model ANOVA comparing proportional DT to the heads between the two facing directions (about-facing, forward-facing) and between the two orientations (WFU, WFI) revealed a main effect of facing direction, $F(1,54) = 84.90$, $p < 0.001$, $\eta_p^2 = 0.61$. Proportional DT to the heads was larger in the forward-facing ($M = 0.23$, $SD = 0.13$) than in the about-facing experiment ($M = 0.02$, $SD = 0.03$). The main effect of orientation was also significant, $F(1,54) = 35.69$, $p < 0.001$, $\eta_p^2 = 0.40$. There was overall greater looking at the heads in the upright ($M = 0.16$, $SD = 0.09$) compared to inverted whole figures ($M = 0.09$, $SD = 0.07$). There was also a significant interaction between facing direction and orientation, $F(1,54) = 32.75$, $p < 0.001$, $\eta_p^2 = 0.38$. For the about-facing experiment, the difference in proportional DT to the heads of the upright and inverted whole figures was non-significant, $t(27) = 0.34$, $p = 0.734$, $d = 0.07$, but for the forward-facing condition, proportional DT was significantly larger to the heads of the upright than the inverted whole figures, $t(27) = 6.29$, $p < 0.001$, $d = 1.19$ (see **Figure 4**).

Bodies (Top of Torso to Ankles)

A 2 × 2 × 2 mixed model ANOVA comparing proportional DT to the bodies between the two facing directions (about-facing, forward-facing), the two body types (whole figure, headless), and the two orientations (upright, inverted) revealed a main effect of facing direction, $F(1,54) = 34.21$, $p < 0.001$, $\eta_p^2 = 0.39$. Proportional DT to the bodies was larger in the about-facing ($M = 0.96$, $SD = 0.05$) than in the forward-facing condition ($M = 0.85$, $SD = 0.11$). There was also a main effect of body type, $F(1,54) = 121.32$, $p < 0.001$, $\eta_p^2 = 0.69$. Proportional DT to the bodies was larger in the headless ($M = 0.96$, $SD = 0.06$) than in the whole figure condition ($M = 0.84$, $SD = 0.10$). There was also a main effect of orientation, $F(1,54) = 12.13$, $p < 0.001$, $\eta_p^2 = 0.18$. Proportional DT to the bodies was larger in the inverted ($M = 0.91$, $SD = 0.08$) than in the upright condition ($M = 0.89$, $SD = 0.08$). The interactions between facing direction and body type, $F(1,54) = 87.34$, $p < 0.001$, $\eta_p^2 = 0.62$, facing direction and orientation, $F(1,54) = 23.45$, $p < 0.001$, $\eta_p^2 = 0.30$, and body type and orientation, $F(1,54) = 27.77$, $p < 0.001$, $\eta_p^2 = 0.34$, were all significant, as was the interaction between facing direction, body type, and orientation, $F(1,54) = 20.50$, $p < 0.001$, $\eta_p^2 = 0.28$. These interactions were explored further. There was significantly greater looking at whole figure bodies (upright and inverted) in the about-facing than in the forward-facing conditions ($ps < 0.001$, corrected ($\alpha \times 4$) ≤ 0.001, $ds > 1.43$, see **Figure 5**), but there was no difference found for headless conditions (upright and inverted, $ps > 0.567$, corrected ($\alpha \times 4$) $= 1.00$). For the about-facing experiment, Bonferroni-corrected *post hoc* comparisons revealed that there was significantly greater looking at the bodies in the HLU condition than in the WFU ($p = 0.003$, corrected ($\alpha \times 6$) $= 0.019$, $d = 0.61$) and WFI conditions ($p = 0.005$, corrected ($\alpha \times 6$) $= 0.027$, $d = 0.58$). The difference in looking

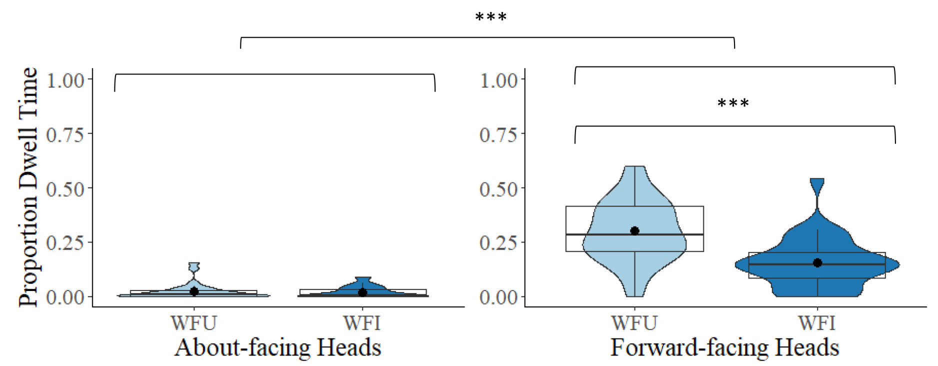

FIGURE 4 | Box and violin plots of proportional dwell time (DT) to the heads (head and neck of the figures) in the WFU and WFI conditions in the about-facing and forward-facing conditions; dots denote means; $^{***}p < 0.001$.

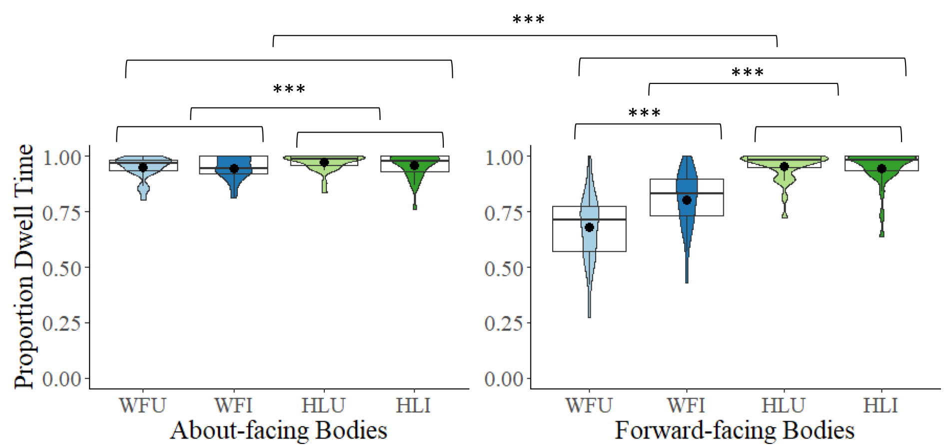

FIGURE 5 | Box and violin plots of proportional dwell time (DT) to the bodies (top of torso to ankles) in the WFU, WFI, HLU, and the HLI conditions in the about-facing and forward-facing conditions; dots denote means; $^{***}p < 0.001$.

at bodies between the upright and inverted headless conditions was non-significant ($p = 1.00$). However, there was significantly greater looking at bodies in the WFI than in the WFU condition ($p < 0.001$, corrected ($\alpha \times 6$) < 0.001, $d = 1.05$. For the forward-facing experiment, there was significantly greater looking at the bodies in the headless (upright and inverted) conditions than in the whole figure (upright and inverted) conditions ($ps < 0.001$, corrected ($\alpha \times 6$) < 0.001, $ds > 1.29$). The difference in looking at bodies between the upright and inverted headless conditions was non-significant ($p = 1.00$). However, there was significantly greater looking at bodies in the WFI than in the WFU condition ($p < 0.001$, corrected ($\alpha \times 6$) < 0.001, $d = 1.05$, see **Figure 5**).

Feet (From Ankles and Bottom of Feet)

A 2 × 2 × 2 mixed model ANOVA comparing proportional DT to the feet between the two facing directions (about-facing, forward-facing), the two body types (whole figure, headless), and the two orientations (upright, inverted) revealed that the main effect of facing direction was non-significant, $F(1,54) = 0.31$, $p = 0.581$, $\eta_p{}^2 = 0.01$. The main effect of body type was significant, $F(1,54) = 5.10$, $p = 0.028$, $\eta_p{}^2 = 0.09$. Proportional DTs were overall greater to the feet in the headless ($M = 0.04$, $SD = 0.06$) than in the whole figure conditions ($M = 0.03$, $SD = 0.05$). The main effect of orientation was non-significant, $F(1,54) = 2.83$, $p = 0.098$, $\eta_p{}^2 = 0.05$. The interactions between facing direction and body type, $F(1,54) = 2.47$, $p = 0.122$, $\eta_p{}^2 = 0.04$, facing direction and orientation, $F(1,54) = 0.02$, $p = 0.880$, $\eta_p{}^2 = 0.01$, and body type and orientation, $F(1,54) = 0.12$, $p = 0.733$, $\eta_p{}^2 = 0.01$, were all non-significant, as was the interaction between facing direction, body type, and orientation, $F(1,54) = 1.97$, $p = 0.167$, $\eta_p{}^2 = 0.04$ (see **Figure 6**).

Relationship Between DT Proportions and Performance

For each condition, the relationship between the DT proportions to each IA and efficiency scores was analyzed to see whether the proportion of time spent looking at particular areas was associated with performance (see **Table 1**). Pearson's r correlations were performed and for the whole figures Bonferroni corrections were applied based on the presence of three IAs ($\alpha \times 3$) and for the headless images, Bonferroni corrections were based on the presence of two IAs ($\alpha \times 2$).

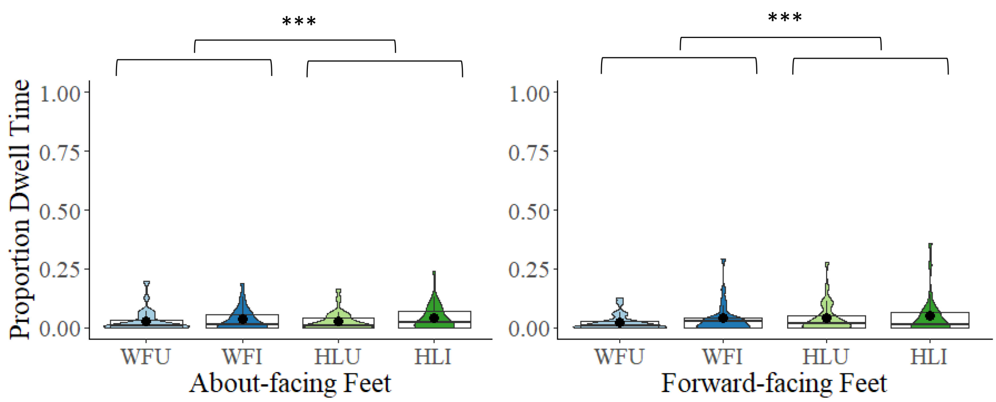

FIGURE 6 | Box and violin plots of proportional dwell time (DT) to the feet (from ankles to bottom of feet) in the WFU, WFI, HLU, and the HLI conditions in the about-facing and forward-facing conditions; dots denote means; *** $p < 0.001$.

TABLE 1 | Pearson's *r* correlations between efficiency scores and proportional dwell time to heads, bodies, and feet.

About-facing efficiency	**Dwell time (DT) proportion**			**Forward-facing efficiency**	**Dwell time (DT) proportion**		
	Heads	**Bodies**	**Feet**		**Heads**	**Bodies**	**Feet**
Whole figure upright				Whole figure upright			
Pearson's *r*	−0.002	0.118	−0.132	Pearson's *r*	0.226	−0.257	0.283
(*p*-value)	(0.992)	(0.548)	(0.503)	(*p*-value)	(0.257)	(0.196)	(0.153)
Corrected *p**	(0.999)	(0.999)	(0.999)	Corrected *p**	(0.771)	(0.588)	(0.459)
95% CIs	−0.375–0.371	−0.266–0.471	−0.481–0.254	95% CIs	−0.168–0.558	−0.580–0.137	−0.109–0.598
Whole figure inverted				Whole figure inverted			
Pearson's *r*	0.436	−0.539	0.329	Pearson's *r*	0.484	−0.499	0.080
(*p*-value)	(0.020)	(0.003)	(0.088)	(*p*-value)	(0.011)	(0.008)	(0.693)
Corrected *p**	(0.060)	(0.009)	(0.264)	Corrected *p**	(0.033)	(0.024)	(0.999)
95% CIs	0.075–0.696	−0.759 to−0.207	−0.051–0.625	95% CIs	0.127–0.730	−0.958 to−0.807	−0.310–0.446
Headless upright				Headless upright			
Pearson's *r*	–	−0.102	0.075	Pearson's *r*	–	−0.215	0.213
(*p*-value)		(0.607)	(0.703)	(*p*-value)		(0.282)	(0.287)
Corrected *p**		(0.999)	(0.999)	Corrected *p**		(0.564)	(0.574)
95% CIs		−0.457–0.282	−0.309–0.436	95% CIs		−0.550–0.180	−0.182–0.548
Headless inverted				Headless inverted			
Pearson's *r*	–	−0.208	0.209	Pearson's *r*	–	−0.423	0.432
(*p*-value)		(0.288)	(0.286)	(*p*-value)		(0.028)	(0.024)
Corrected *p**		(0.576)	(0.572)	Corrected *p**		(0.056)	(0.048)
95% CIs		−0.539–0.179	−0.178–0.540	95% CIs		−0.692 to −0.051	0.062–0.697

**Bonferroni corrections (α × 3 for each whole figure condition and α × 2 for each headless condition).*

Whole Figure Upright Images

In both the about- and forward-facing conditions, there were no significant relationships between DT proportions to any of the IAs and efficiency scores, *rs* < 0.257, *ps* > 0.196.

Whole Figure Inverted Images

In both the about- and forward-facing conditions, there was a significant negative relationship between DT proportions to the bodies and efficiency scores, *rs* > -0.499 (Bonferroni-corrected *ps* < 0.008). In the forward-facing condition there was a significant positive relationship between DT to the heads, $r = 0.484$ (Bonferroni-corrected $p = 0.033$); and in the about-facing condition there was a similar non-significant trend $r = 0.436$ (Bonferroni-corrected $p = 0.060$). These findings suggest that when the whole figures are inverted, the more participants look at the bodies and the less they look at the heads, the better their performance.

Headless Upright Images

In both the about- and forward-facing conditions, there were no significant relationships between DT proportions to any of the IAs and efficiency scores (see **Table 1**).

Headless Inverted Images

In the about-facing condition, there were no significant relationships between DT proportions and efficiency scores. In the forward-facing condition, there was a significant positive relationship between looking at the feet and efficiency scores, $r = 0.432$ (Bonferroni-corrected $p = 0.048$) and a non-significant negative trend for looking the bodies and efficiency scores $r = -0.423$ (Bonferroni-corrected $p = 0.056$). This suggests that the less participants looked at the feet and the more they looked at the bodies the better the performance.

DISCUSSION

Analyzing both *d*' and efficiency scores revealed BIEs with the whole figures in both the about- and forward-facing images, replicating previous studies (Minnebusch et al., 2009; Brandman and Yovel, 2010, 2012; Yovel et al., 2010; Robbins and Coltheart, 2012b; Arizpe et al., 2017). For the headless images, there was no BIE for forward-facing images with efficiency scores, but there was a BIE with *d*' scores, again like previous studies which have sometimes showed BIEs for headless bodies and sometimes not (e.g., Yovel et al., 2010; Arizpe et al., 2017). The never before tested about-facing headless bodies showed no BIE with either measure.

Therefore, we do find a forward-facing headless BIE with *d*' scores, but the magnitude of the BIE did not differ significantly between the whole figure and headless conditions. For the about-facing condition, the magnitude of the BIE (based on *d*' scores) was larger in the whole figure compared to the headless conditions, due to the absence of a BIE in the about-facing headless condition. Participants were also more conservative, responding "same," whether correct or incorrect, in the about-facing inverted headless than in the upright headless condition. As there was a forward-facing headless BIE, this suggests that even without head information, when people are seen from a frontal view, the advantage of seeing the images in an upright compared to an inverted orientation leads to similar effects as is seen with whole figures. Note, effect sizes in both the about-facing and forward-facing conditions tended to be medium for the whole figures and small for the headless figures. This is consistent with the findings of Arizpe et al. (2017).

Brandman and Yovel (2012) suggested that the BIE might be based on the presence or induced presence of a face and provided evidence that people were more likely to imagine faces in briefly presented stimuli with images that were also found to have larger BIEs, namely (faceless) forward-facing whole figures, suggesting a role of contextual priming. The condition that did not fit with that trend in their study was the about-facing whole figures, for which people did not imagine a face, but which showed a BIE, albeit smaller in magnitude than in the forward-conditions. An extension to this interpretation might be that BIEs are weaker for bodies presented in less typical forms (i.e., about-facing, headless), which would predict a BIE for whole figures seen from behind, but smaller BIE for bodies without heads. Unlike Brandman and Yovel (2010) we failed to see any difference in BIEs between the forward- and about-facing conditions and we also find a headless BIE in the forward-facing condition (with *d*' only). Performance was overall better in the forward-facing conditions suggesting that faces (present or induced in the case of headless bodies) might contribute to better body posture discrimination. We also see a larger BIE in the about-facing whole figure compared to the headless condition. This pattern of BIEs, suggests that the BIE weakens as bodies appear in a less typically experienced form and in forms where heads are least likely to be induced, such as in headless, about-facing presentations.

The question of contextual priming raises another related question, that of repetition priming, or a combination of repetition and contextual priming. If bodies are seen with a head and then without a head there is a chance that the face is more likely to be perceived. In the current study, and most others, this is the design. The whole and headless figures were presented within-groups so that the relative size of the BIEs could more accurately be compared. Yovel et al. (2010) and Brandman and Yovel (2010, 2012) used between groups designs to reduce the chance of such priming, with the major downside being that the groups were small. We also tested one of our conditions between groups – that of forward- versus about-facing. If priming were the only thing leading to a BIE for headless figures, then it seems likely that we should have found some indication of this for about-facing as well as forward-facing figures, but we did not as there was no BIE in the about-facing headless condition. This further supports our argument that the BIE is strongest for the most prototypical or most frequently experienced body – forward-facing and with a head. Reed et al. (2006) showed that BIEs were larger for whole intact bodies than scrambled bodies. Reed et al. (2012) tested the role of experience in a different way showing people computer-generated human or dog figures in human or dog poses. The most commonly experienced canonical poses (humans in human poses) showed the largest inversion effects, whereas inversion effects were smaller for dogs in human poses and humans in dog poses. Interestingly, there were no inversion effects for dogs in dog poses, which Reed at al. interpret as showing that it is the embodied experience as well as the visual experience that matters.

What role then does facial or even induced facial information play? As mentioned, Brandman and Yovel (2012) found that participants reported seeing (absent) facial features at higher rates in forward-facing than in about-facing whole figures for very briefly presented stimuli. Here using photographic images of people, proportional looking to the heads was larger in the forward- than the about-facing images and larger for the upright than the inverted forward-facing heads. This was despite participants engaging in *body* posture discrimination task and the head information between the pairs being identical. Looking at heads should have conferred no advantages. There was also less looking at bodies in the forward-facing upright images than inverted images or about-facing images, and overall less looking at bodies in the upright compared to the inverted images. Nonetheless, there were better *d*' scores in the forward- than in the about-facing condition and better scores in the upright compared to the inverted whole figures. Therefore, greater looking times at the bodies does not necessarily explain participants' performance. Does this mean that greater looking to the heads instead explains participants' performance? Correlations revealed that there was no direct evidence for greater DT proportions to heads and better performance.

There was also a headless BIE in the forward-, but not the about-facing conditions (for *d*' scores). Heads are of course absent in the headless condition, but heads are attached to bodies. Therefore, faces might be more easily induced with forward-facing than with about-facing headless bodies. As mentioned, directly looking at heads might not be necessary for a BIE given that the correlations between DT proportions to heads and performance were weak and we find a headless BIE (forward-facing) and a BIE with about-facing whole figures. Arizpe et al. (2017), found that focusing on the upper torso or head in both orientations was associated with better performance, so it might be a combination of the two areas. We also found that in the HLI condition (forward-facing), the longer the DT proportion to the feet the poorer the performance, which is similar to Arizpe et al. (2017). Brandman and Yovel (2010) did not ask participants if they saw faces in briefly presented inverted images, so it is uncertain how much faces are perceived in inverted images, but presumably less so than with upright images; and this might explain the poorer performance with inverted figures.

What we did find is that with inverted whole figures, a greater focus on bodies and less on heads was associated with better performance, particularly in the forward-facing condition. Our findings, therefore, also suggest that when the task is more difficult as it is with a less typical body format such as inverted bodies, a greater focus on bodies and less on heads or feet is associated with better performance. Therefore, when upright, the more easily induced the face and the more typical the images, the better the performance; and when inverted a stronger focus on the bodies is associated with better performance.

Inversion effects are often taken as an indirect measure of holistic or configural processing (see extensive discussion of this in Robbins and McKone, 2007). Although inversion effects are found for many stimuli with a canonical upright orientation, they tend to be stronger for faces and human bodies (e.g., Reed et al., 2003; Yovel et al., 2010; Robbins and Coltheart, 2012b). A few studies have also used a more direct measure of holistic processing in bodies, the composite task. In the original version of this task, top and bottom halves from two different faces are combined and it is harder to name one half when the two are aligned than when they are misaligned (Young et al., 1987). In the matching version of this task, participants are asked to say whether the top, bottom, left or right halves of a pair of items are the same or different while ignoring the other half, and again the task is harder for aligned than misaligned stimuli (e.g., Robbins and McKone, 2007). Robbins and Coltheart (2012a) found that whole bodies with heads, but obscured faces, are holistically processed in the matching version of the composite task. Similarly, Willems et al. (2014) found composite effects for bodies with heads (showing faces) in a posture matching task. Bauser et al. (2011) found no holistic processing for bodies with heads or without heads on the composite task, but the clothes were so different that the task could be done without looking at identity, making the lack of a composite effect less surprising. Thus, it is not known whether there is a composite effect for headless bodies. As for findings that a BIE is typically found with figures with more easily induced faces, results from the composite task could be because faces are induced, which contributes to holistic/configural processing of bodies when upright due to activation of the face-selective brain regions as first proposed by Brandman and Yovel (2010) and Yovel et al. (2010).

One limitation of this study is that we did not have faceless, forward-facing whole figures making it difficult to compare our findings to others, which largely had faceless heads (e.g., Yovel et al., 2010; Arizpe et al., 2017). Participants here looked longer at the forward- than at the about-facing heads. By including a faceless forward-facing condition, we could also more directly compare the effect of the presence of faces on the BIE in forward-facing images. Further, Brandman and Yovel (2012) found a significantly smaller BIE in the about- compared to the forward-facing images while we did not find a difference. Both this study and theirs was between groups for facing direction and perhaps a within groups design could help to elucidate this difference.

CONCLUSION

In conclusion, consistent with the literature (e.g., Brandman and Yovel, 2012; Arizpe et al., 2017), we find a consistent BIE with whole figures whether they are about- or forward-facing. The BIE with the headless images was less consistent. Arizpe et al. (2017) argued that the headless BIE is weaker than the whole figure BIE and the presence or absence of a headless BIE is more susceptible to statistical power. The sample size here was likely sufficient as the forward-facing headless BIE was similar in magnitude to the forward-facing whole figure BIE, but there were weaker effect sizes in the headless conditions. In the about-facing condition, the magnitude of the BIE was smaller (and absent) for the headless than for the whole figure images. Therefore, the presence or strength of the BIE is likely due to a combination of the likelihood that a face can be induced and the more prototypical the format of the figure is (whole figure, upright, or forward-facing for headless images). Faces are more easily induced with more prototypical presentations such as with WFU images (Brandman and Yovel, 2012). A further unique finding here is that participants looked at the forward-facing heads more than the about-facing heads even though the heads of the test pairs in each condition were identical and therefore were not informative for the task. However, looking at heads was not directly associated with better performance. Participants also looked more at the inverted than the upright bodies and the headless than the whole figure bodies. Greater looking at inverted whole figure bodies was associated with better performance, but the relationship between looking at upright bodies and performance was weak. Therefore, a focus on faces or bodies *per se* does not explain performance. Instead, a BIE is more reliable when the figures are seen in their most typical format, and when the face is more easily induced, as is the case with upright images, This might lead to better performance as configural processing might be stronger, which in turn might lead to better discrimination. When the task is more difficult, as with inverted images, a focus on bodies is associated with better performance.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

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

AUTHOR CONTRIBUTIONS

EA, RR, and HFC wrote the manuscript. EA and HFC were involved in the study design and analyses. HFC and HWC collected the data. EA, RR, HFC, and HWC contributed intellectually to the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02686/full#supplementary-material

REFERENCES

Arizpe, J. M., McKean, D. L., Tsao, J. W., and Chan, A. W. (2017). Where you look matters for body perception: preferred gaze location contributes to the body inversion effect. *PLoS One* 12:e0169148. doi: 10.1371/journal.pone.0169148

Bauser, D. A. S., Suchan, B., and Daum, I. (2011). Differences between perception of human faces and body shapes: evidence from the composite illusion. *Vis. Res.* 51, 195–202. doi: 10.1016/j.visres.2010.11.007

Brandman, T., and Yovel, G. (2010). The body inversion effect is mediated by face-selective, not body-selective mechanisms. *J. Neurosci.* 30, 10534–10540. doi: 10.1523/JNEUROSCI.0911-10.2010

Brandman, T., and Yovel, G. (2012). A face inversion effect without a face. *Cognition* 125, 365–372. doi: 10.1016/j.cognition.2012.08.001

Bruyer, R., and Brysbaert, M. (2011). Combining speed and accuracy in cognitive psychology: is the inverse efficiency score (IES) a better dependent variable than the mean reaction time (RT) and the percentage of errors (PE)? *Psychol. Belg.* 51, 5–13. doi: 10.5334/pb-51-1-5

Diamond, R., and Carey, S. (1986). Why faces are not special: an effect of expertise. *J. Exp. Psychol.* 115, 107–117. doi: 10.1037/0096-3445.115.2.107

Farah, M. J., Tanaka, J. W., and Drain, H. M. (1995). What causes the face inversion effect? *J. Exp. Psychol. Hum. Percept. Perform.* 21, 628–634. doi: 10.1037//0096-1523.21.3.628

Minnebusch, D. A., Suchan, B., and Daum, I. (2009). Losing your head: behavioral and electrophysiological effects of body inversion. *J. Cogn. Neurosci.* 21, 865–874. doi: 10.1162/jocn.2009.21074

Reed, C. L., Nyberg, A. A., and Grubb, J. D. (2012). Contributions of visual and embodied expertise to body perception. *Perception* 41, 436–446. doi: 10.1068/p7029

Reed, C. L., Stone, V. E., Bozova, S., and Tanaka, J. (2003). The body-inversion effect. *Psychol. Sci.* 14, 302–308. doi: 10.1111/1467-9280.14431

Reed, C. L., Stone, V. E., Grubb, J. D., and McGoldrick, J. E. (2006). Turning configural processing upside down: part and whole body postures. *J. Exp. Psychol. Hum. Percept. Perform.* 32, 73–87. doi: 10.1037/0096-1523.32.1.73

Robbins, R. A., and Coltheart, M. (2012b). The effects of inversion and familiarity on face versus body cues to person recognition. *J. Exp. Psychol. Hum. Percept. Perform.* 38, 1098–1104. doi: 10.1037/a0028584

Robbins, R. A., and Coltheart, M. (2012a). Left-right holistic integration of human bodies. *Q J. Exp. Psychol.* 65, 1962–1974. doi: 10.1080/17470218.2012.674145

Robbins, R. A., and McKone, E. (2007). No face-like processing for objects-of-expertise in three behavioural tasks. *Cognition* 103, 34–79. doi: 10.1016/j.cognition.2006.02.008

Rossion, B. (2008). Picture-plane inversion leads to qualitative changes of face perception. *Acta Psychol.* 128, 274–289. doi: 10.1016/j.actpsy.2008.02.003

Stanislaw, H., and Todorov, N. (1999). Calculation of signal detection theory measures. *Behav. Res. Methods Instrum. Comput.* 31, 137–149. doi: 10.3758/bf03207704

Susilo, T., Yovel, G., Barton, J. J. S., and Duchaine, B. (2013). Face perception is category-specific: evidence from normal body perception in acquired prosopagnosia. *Cognition* 129, 88–94. doi: 10.1016/j.cognition.2013.06.004

Willems, S., Vrancken, L., Germeys, F., and Verfaillie, K. (2014). Holistic processing of human body postures: evidence from the composite effect. *Front. Psychol.* 5:618. doi: 10.3389/fpsyg.2014.00618

Young, A. W., Hellawell, D., and Hay, D. C. (1987). Configurational information in face perception. *Perception* 16, 747–759. doi: 10.1068/p160747

Yovel, G., Pelc, T., and Lubetzky, I. (2010). It's all in your head: why is the body inversion effect abolished for headless bodies? *J. Exp. Psychol. Hum. Percept. Perform.* 36, 759–767. doi: 10.1037/a0017451

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The Impact of a Dissonance-Based Eating Disorders Intervention on Implicit Attitudes to Thinness in Women of Diverse Sexual Orientations

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Dissonance-based body image programs have shown long-term effectiveness in preventing eating disorders and reducing risk factors for eating disorders in women. Here we report on the potential for one such intervention to impact on implicit attitudes toward thinness as well as an explicit measure of eating attitudes, across a sexually diverse group of young women. The Succeed Body Image Programme was adapted to remove heteronormative assumptions and was delivered to a final sample of 56 undergraduate women who reported their sexual orientation as either "predominantly heterosexual" (our term; 1 or 2 on a 7-point Kinsey scale, $n = 38$) or non-heterosexual (3–7 on the Kinsey scale, $n = 18$). Before and after the intervention, they completed the Eating Attitudes Test-26, and an associative reaction time task based on the Implicit Association Test, in which bodies of low and higher weight were paired with socially desirable or undesirable traits. A total of 37 predominantly heterosexual women completed a control intervention in which they read NHS leaflets on eating disorders and healthy weight. Results showed that the intervention made predominantly heterosexual participants less prone, versus control, to associating thinness with positive traits on the IAT and all women completing the intervention reported a lower level of disordered eating attitudes at post- than pre-test. Non-heterosexual women, however, showed a non-significant increase in thin-bias on the IAT, perhaps due to their low baseline. These results imply that intensive dissonance-based programs can change attitudes at the automatic, implicit level as well as merely giving women tools to overcome those implicit attitudes.

Keywords: cognitive dissonance, body image, intervention, eating disorders, implicit attitudes

INTRODUCTION

Eating disorders are not only accompanied by a wide range of chronic symptoms functionally impairing the whole body but also increase the future risk of depression, obesity, and anxiety disorders among other psychological issues (Stice and Bearman, 2001; Stice et al., 2013). They have the highest mortality rate of any group of psychiatric disorders (Harris and Barraclough, 1998;

Keshaviah et al., 2014), and relapse rates following treatment typically exceed 30% (Olmsted et al., 2015; Berends et al., 2018). Treatment attrition is similarly high (DeJong et al., 2012; Vall and Wade, 2015), underscoring the importance of efforts to prevent the initial development of disordered eating symptoms in higher risk populations, such as young women (Austin, 2016).

Key risk factors in the development of eating disorders are negative body image and appearance pressures (e.g., Stice, 2002; Stice et al., 2010), in particular a focus on achieving an unrealistically proportioned, unattainable thin ideal commonly promoted in Western media (Tiggemann and Miller, 2010; Cash and Smolak, 2011). Efforts to reduce eating disorder prevalence have found some success in the use of dissonance-based persuasion theories (Stice and Shaw, 2004; Becker and Stice, 2011). Indeed, a recent review concluded that dissonance-based prevention interventions were most effective in reducing eating disorder risk for higher risk populations (Watson et al., 2016). One such intervention is the Succeed Body Image Programme (SBIP; Becker and Stice, 2011, 2012), a UK adaption of peer-led workshop, Reflections, originally delivered *via* American sororities (Becker et al., 2005). A key aspect of the program requires women to actively criticize the thin-ideal standard of beauty *via* roleplays, letter writing, group discussions, and self-affirmation exercises. It is proposed that the inconsistency between these behaviors and their previous internal attitudes generates cognitive dissonance, which participants resolve by decreasing their internal adherence to the thin ideal, resulting in decreased body dissatisfaction, and decreases in eating disorder symptoms and unhealthy weight control behavior long after the intervention is finished (Becker et al., 2005). Indeed, this approach shows long-lasting improvement in eating disorder risk factors and symptoms in various environments for at least 3 years (e.g., Stice et al., 2008; Kilpela et al., 2014).

The current study sought to further understand the effectiveness of an eating disorder prevention program on two counts. Firstly, our primary aim was to assess the implicit versus explicit change in participants' attitudes following the intervention in order to better understand the degree to which the program is truly internalized. We also had a secondary aim to consider how broadly applicable the program was to women of diverse sexuality.

Implicit Attitudes

Despite well-documented decreases in eating disorder risk, however, the mechanism by which these improvements come about remains opaque. While cognitive dissonance purports to induce genuine change in attitudes, the outcomes tested in the research into eating disorder prevention have almost entirely been explicit, self-report measures which are inherently open to self-report bias (for key reviews see, e.g., Stice and Shaw, 2004; Pennesi and Wade, 2016; Stice et al., 2019). For instance, it may be that participation in body-positive interventions helps participants to ignore their internalized thin ideals without actually changing those internal ideas, or the intervention may lead them to believe that reporting such ideals is socially undesirable, and thus under-report their internal ideals and eating disorder symptomology.

One study of note avoided the risks of report or presentation bias by considering fMRI evidence, finding that participants who completed the dissonance program showed reduced responsivity in reward pathways, specifically in the caudate, when viewing stimuli representing thin models (Stice et al., 2015). The current study investigated the impacts of dissonance programs on internal attitudes through another means: by testing whether participation in the Succeed program can alter not only traditional explicit measures of eating disorder symptomology (the Eating Attitudes Test-26: Garner et al., 1982), but also implicit bias toward thinness.

Testing implicit attitudes has been hypothesized to allow researchers to access stimulus associations which participants may not have conscious access to, or may consciously attempt to over-ride when reporting on explicit measures (see, e.g., Wilson et al., 2000; Gawronski and LeBel, 2008). In the current study, we used a reaction time task based on the Implicit Association Test (IAT) (Greenwald et al., 1998), to test the relative automaticity of participants' ability to pair slimmer bodies with more positively valenced words and vice versa.

Previous studies looking at how dissonance may change implicit attitudes have not generally found support for such an effect. For instance, Gawronski and Strack (2004) found that essay-based dissonance tasks on both alcohol and positive discrimination were able to shift explicit attitudes but did not change implicit attitude scores to these issues. Indeed, Gawronski and colleagues (Gawronski and Strack, 2004; Hofmann et al., 2005; Gawronski and Bodenhausen, 2006; Gawronski et al., 2007; Gawronski and LeBel, 2008) have argued that explicit attitudes are inherently representational while implicit attitudes are distinct in terms of being automated and associative, and thus dissonance should act at the representational level and not the associative. Related to this, interventions that have changed implicit attitudes have often used associative techniques to do so. For instance, on a conceptually related topic to ours, implicit self-esteem has been changed through training of associations (e.g., Grumm et al., 2009) and even by using the IAT as a means to help participants practice positive-self associations (Ebert et al., 2009).

Critically, although Succeed puts cognitive dissonance at the center of its approach to improving body image, it also differs considerably from standard experimental approaches to studying dissonance. Participants engage in not just one dissonance activity, but multiple exercises in varying forms (e.g., letter writing, role playing, reporting on activities to the group), spread across two 2-h sessions and homework in between. Furthermore, some of the exercises explicitly involve practicing positive body associations (e.g., practicing positive affirmations and self-complements out loud; see **Supplementary Materials** for more detail). As such the material incorporates elements that could be considered as practicing evaluative practice (both positive about the self, and negative regarding the thin ideal) and thus may be considerably more likely to induce changes at the implicit level than standard experimental interventions such as induced compliance in an essay writing task.

The primary aim of the current study was therefore to consider whether the Succeed program could impact on implicit attitudes to thinness. Assessing efficacy *via* implicit and explicit outcomes may deliver a holistic understanding of how they independently and synergistically predict thin-ideal adherence and disordered eating. Therefore, this study examined implicit changes, alongside explicit changes, *via* an Implicit Association Test-based task (IAT) and the Eating Attitudes Test-26 (EAT-26; Garner et al., 1982) respectively.

Sexual Orientation and Body Dissatisfaction

A secondary aim of the current study was to consider sexual orientation as a potential moderator of program outcomes. The literature shows mixed findings regarding whether sexual minority women have higher risk (e.g., Austin et al., 2013; Matthews-Ewald et al., 2014) or lower risk (e.g., Owens et al., 2002; Diemer et al., 2015) of eating disordered behaviors. Some studies find that bisexual women are more at risk than lesbians (e.g., Austin et al., 2009; Polimeni et al., 2009), while other data suggests the risk among lesbians may be increasing over time (Watson et al., 2017). Studies focusing specifically on body image are likewise ambiguous. Some studies comparing lesbians with heterosexual women have tended to find that lesbians experience less body dissatisfaction and/or less weight preoccupation, and have higher body weight ideals, than heterosexual women (e.g., Strong et al., 2000; Morrison et al., 2004; Peplau et al., 2009). However, other recent studies also including bisexual women failed to find any group differences in body dissatisfaction (e.g., Davids and Green, 2011; Antfolk et al., 2017). This picture is further complicated by the fact that the drivers of body dissatisfaction and eating pathology may also differ between heterosexual individuals and those in sexual minorities (Davids and Green, 2011; Alvy, 2013; Huxley et al., 2015; Watson et al., 2015). As such, considering the potential for body image programs such as Succeed to benefit non-heterosexual women is important. Because the program materials as originally written are often heteronormative, we adjusted terminology to make the materials applicable to non-straight women; for instance one roleplay involving a young woman wanting to be thin for her boyfriend was removed, and other references to partners were made gender neutral (see Brown and Keel, 2015, and Jankowski et al., 2017, for related discussion of adapting these interventions for gay men).

We therefore recruited participants through LGBTa+ societies as well as more typical routes, in order to consider whether sexual orientation predicted improvements in eating attitudes and IAT scores across the experiment.

METHODS

Participants

One hundred and twenty-five women were initially recruited. A mostly heterosexual sample was recruited through participant pools and word of mouth, while recruitment of non-heterosexual women was primarily through the LGBTa+ Societies of three British universities in North East England. Our recruitment strategy was to recruit as many participants as possible within the time-frame available to the two student authors (RK, AWC). All participants were ascribed female at birth and had a female gender identity. Following exclusions for elevated eating disorder symptoms and immediate withdrawals, 102 women aged 18–30 years (mean 19.4) took part in the study, of whom 93 provided complete questionnaire data at both time points (9 participants completed pre-test but not post-test), and 70 provided complete IAT data at both time points (more data were lost for the IAT due to the difficulties some participants had completing the test on their personal computers or devices). Participants who failed to complete post-test measures did not differ from other participants on pre-test EAT-26 scores, but did show higher pro-thin bias on the IAT (see **Supplementary Materials**).

Ethics

The study was approved by the Durham University Psychology Ethics Committee. Following committee stipulations, study advertisements asked those with a current diagnosis of an eating disorder not to participate, and 13 individuals with a baseline score above 25 on the EAT-26 were excluded from the study. All participants were supplied with details of the university counseling services and eating disorder information sources on completion of the study.

Experimental Groups

Participants reported their sexual orientation on a 7-point Kinsey scale (Kinsey et al., 1948) from 1 (exclusively opposite sex preference) to 7 (exclusively same sex preference). This allows more variation in sexual orientation than a simple "heterosexual," "bisexual," and "homosexual" identity categorization. Unfortunately, while there was strong representation of women scoring 1 and 2 (exclusively or almost exclusively heterosexual) in control and intervention conditions, only six women scoring 3 or more provided control group data (some of which was incomplete). We therefore divided our participants into three groups: the control group (predominantly heterosexual; Kinsey scores below 3, final $n = 38$); a predominantly heterosexual intervention group (Kinsey scores below 3, final $n = 18$); and a non-heterosexual intervention group (Kinsey scores all above 4; no women scoring 3 took part in the intervention, final $n = 31$).

Outcome Measures

Eating Attitudes Test

The 26-item self-reported EAT-26 (Garner et al., 1982) is a Likert-scale dimensional measure of eating disorder symptoms, which asks participants to report the frequency of behaviors and thoughts such as avoidance of fat-rich foods, monitoring of calories consumed, feeling pressure or concern about their weight, and active bulimic behaviors. Although the measure can be broken into three sub-scales (*Dieting, Bulimia & Food Pre-occupation* and *Oral Control*), the total scores are also informative and were used here. Cronbach's alpha for internal consistency in the current sample was good ($\alpha = 0.79$).

Implicit Association Test

Participants completed a two-choice reaction time task, based on the IAT. In a block of 16 trials, participants pressed the C-left or M-right key to indicate whether the stimulus fitted the categories on the left or right of the screen; these categories were either good/fat vs. bad/thin or good/thin vs. bad/fat. Stimuli were either words (4 "good" – beautiful, desirable, happy, successful, 4 "bad" – ugly, repellent, miserable, failure, each presented twice) or computer-generated images of women with putative BMIs of 17.2 and 30.9 (see Boothroyd et al., 2012, for more detail on how stimuli were constructed; example figures are shown in **Figure 1**). Participants completed 16 trials of words, then 16 trials of images, followed by 32 trials of words and images randomly interspersed, for a given category combination. They then completed the same process with the opposite combination. Once a stimulus was categorized correctly the stimulus was removed and the next stimulus was presented after a 400-ms delay. Incorrect categorization was indicated with an X, which remained on screen until the correct key was pressed. Participants were urged to complete the test quickly with minimal mistakes. Order of category pairings (thin + good versus thin + bad) and within-block stimuli were randomized to counterbalance participant practice effects. Implicit thin-ideal IAT D scores, which indicate the relative bias in reaction times to one combination of pairings vs. the other, controlling for participants' general reaction time distribution, were calculated as per Greenwald et al. (1998).

Procedure

Participants completed the consent form and the EAT-26 and IAT online at the point of recruitment and were allocated to complete either (1) the experimental Succeed Body Image Programme (SBIP) (final n = 56 with at least complete EAT-26 data) or (2) read NHS leaflets (final n = 37).

The Becker and Stice (2011) SBIP intervention was conducted across two 2-hour sessions, led by Succeed-trained peers, held a week apart in groups of 6–10 participants. The SBIP presented participants with information about the dangers of pursuing the thin ideal and the benefits of a healthy body ideal. Participants completed activities such as roleplays in which a "friend" had to be persuaded to reject the thin ideal, mirror tasks to notice one's positive attributes, practice of affirmations, or strategies to avoid future body concerns and an empathetic letter to a struggling teenage girl explaining the biological, social, or financial damage of pursuing the thin-ideal. Further details of the activities are given in the **Supplementary Materials**.

Control group participants read National Health Service (NHS) leaflets titled (1) Eating Disorders (see most recent

FIGURE 1 | Example stimuli showing the slimmer and larger bodies used in the IAT.

online version here: https://www.nhs.uk/conditions/eating-disorders/) and (2) Eating a Balanced Diet (see most recent online version here: https://www.nhs.uk/live-well/eat-well/), which included mental and physical health information similar to the SBIP but without the dissonance or practice elements. The Eating Disorders leaflet elaborated on the causes, symptoms, and treatments of varying eating disorders whereas the Balanced Diet contained material on the Eatwell plate and appropriate balance of food types.

A week after concluding the second session of the SBIP (or a similar time frame from baseline for those reading the NHS leaflets), participants completed the EAT-26 and IAT again. There was typically a 4-week interval between the baseline and post-test measures.

RESULTS

Table 1 shows correlations between variables for the full sample and for those with complete data on the EAT-26 or IAT. IAT and EAT-26 scores were not associated at baseline or post-test.

To test the effect of the SBIP intervention on eating attitudes and implicit thin-bias, repeated measures ANOVAs were run in SPSS 22, where time (pre-test or post-test) was the within-subjects variable and group (Succeed (predominantly heterosexual), Succeed (non-heterosexual), or control) was a between-subjects measure. Full results are shown in **Table 2**. For EAT-26 scores, the model showed no main effect of group. There was, however, a significant group by time interaction. Paired analyses within group showed that participants in both intervention groups experienced a significant decrease in their levels of disordered eating attitudes (predominantly heterosexual: $t = 3.917$, df = 37, $p < 0.001$; non-heterosexual $t = 3.480$, df = 17, $p = 0.003$) but the control group showed no such change ($t = 0.992$, df = 36, $p = 0.328$). Data are illustrated in **Figure 2**, and all means are given in **Supplementary Materials**.

There was a significant main effect of group for IAT score. As seen in **Figure 2**, women in the non-heterosexual group had overall IAT scores lower than the predominantly heterosexual groups (Tukey's *post hoc* comparisons significant with $p < 0.02$). In fact, the mean at baseline was close to zero, indicating no pro- or anti-thin bias. There was also a significant interaction between time and group. Paired *t*-tests showed a significant drop in thin-bias in the predominantly heterosexual Succeed intervention group ($t = 2.812$, df = 24, $p = 0.010$). There was no change in the control group ($t = 0.609$, df = 20, $p = 0.550$). The non-heterosexual Succeed group showed a non-significant trend toward stronger pro-thin bias at post-test ($t = 2.103$, df = 15, $p = 0.053$).

TABLE 1 | Correlations between eating attitudes, sexual orientation, and IAT D scores for all eligible participants (above the diagonal) and those with complete IAT or EAT-26 data (below the diagonal).

		EAT-26 pre-test	EAT-26 post-test	IAT pre-test	IAT post-test
EAT-26	*r*		0.554**	0.057	0.196
pre-test	p		<0.000	0.598	0.121
	n		87	89	64
EAT-26	*r*	0.554**		0.059	0.074
post-test	*p*	<0.000		0.602	0.570
	n	63		80	61
IAT	*r*	0.177	0.115		0.161
pre-test	*p*	0.169	0.372		0.212
	n	62	62		62
IAT	*r*	0.165	0.081	0.134	
post-test	*p*	0.207	0.539	0.312	
	n	60	60	59	

***Correlation is significant at the 0.001 level (2-tailed).*

TABLE 2 | Results of ANCOVA models for effects of intervention on EAT-26 and IAT scores.

	df	*F*	*p*	Partial eta squared
EAT-26				
Group	2.84	1.278	0.284	0.030
Time	1.84	14.438	0.000	0.147
Group × time	**2.84**	**7.400**	**0.001**	**0.150**
IAT				
Group	2.59	84.371	0.000	0.588
Time	1.59	0.514	0.476	0.009
Group × time	**2.59**	**6.568**	**0.003**	**0.182**

The key test of the experimental effect is the group by time interaction, shown in bold.

DISCUSSION

The current study investigated the effect of the Succeed Body Image Programme, a cognitive-dissonance eating disorder intervention, on explicit and implicit measures of eating attitudes and thin-bias respectively, in a sexually diverse group of female undergraduates. Results showed a significant effect of the intervention on participants' explicit self-reports of pathological eating attitudes, in both the predominantly heterosexual, and the non-heterosexual groups. On the other hand, implicit thin bias was significantly reduced by the intervention only among the predominantly heterosexual group. Although all "predominantly heterosexual" participants showed longer response times to the counter-cultural thin-bad/fat-good trials than the concordant thin-good/fat-bad trials, this effect became weaker between baseline and post-test in those who had completed the intervention, while those who had read NHS leaflets showed no change. Surprisingly, although the non-heterosexual group started off showing no pro- or anti-thin bias, following the intervention they did show a pro-thin bias (although we note the paired *t*-test for this group did not quite reach significance.)

Our results for EAT-26 questionnaire data are consistent with recent systematic reviews of dissonance intervention trials which

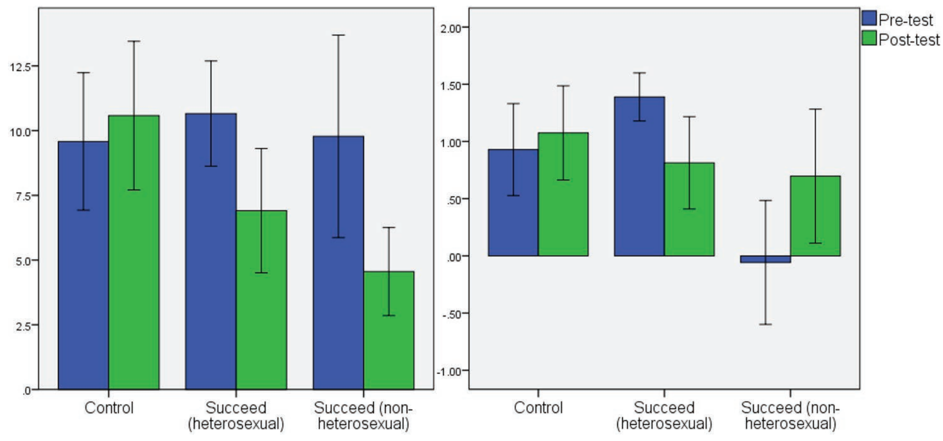

FIGURE 2 | Mean scores with 95% confidence intervals for the association between time (pre-test and post-test) and group on EAT-26 scores (left panel) and IAT scores (right panel).

similarly produce reductions in eating disorder risk factors, such as thin-ideal internalization, body dissatisfaction, and self-reported dieting in intervention participants (see Pennesi and Wade, 2016, for review of all studies). Demonstrating an effect of this intervention on implicit attitudes among predominantly heterosexual women, *via* response latencies, is novel evidence that extensive dissonance interventions may indeed change underlying associative cognitions as well as explicit, self-reported beliefs among these participants. Because implicit measures are ostensibly not subject to response bias (Gawronski et al., 2007), it is unlikely that our participants were merely suppressing their thin-ideal associations in the intervention group. Rather it seems more likely that the repeated practice of these body-positive associations enabled genuine implicit change. Furthermore, our responses are consistent with those of Stice et al. (2015) who showed that completion of a similar dissonance-based program reduced neurological reward responses to thin-ideal imagery. Both their data and ours point toward the interventions reducing the overall positive associations with thinness in participants.

The SBIP meets the "gold standard" for eating disorder prevention *via* body image resilience, with effectiveness appearing to rest on it being interactive, multi-sessional, and dissonance-based instead of being didactic, single session, and psychoeducational (Stice and Shaw, 2004; Stice et al., 2019). As discussed above, however, traditional dissonance interventions have had difficulty in inducing implicit changes in participants. It seems likely therefore, that the repeated practice of positive associations and anti-thin-ideal associations may contribute to the implicit changes observed here in the predominantly heterosexual intervention group, beyond the simple inclusion of dissonance. Given that one arm of the program is to equip women with affirmations that they can repeat to themselves regularly and at key junctures in the future, it is possible that testing implicit attitudes further from the point of intervention may show stronger effects.

It remains puzzling, however, why non-heterosexual women should appear to benefit from the Succeed intervention in terms of their self-reported eating attitudes, but show a trend toward an inverse relationship for their implicit attitudes. One possibility is that their very lack of such implicit bias at baseline meant that discussion of the thin ideal during the sessions actually strengthened the salience of this stereotype and thus rendered them more prone to a bias in response latencies. As such, although we can conclude from the current study that the intervention seemed to work as intended among this diverse sample of women as far as explicit eating attitudes are concerned, we cannot draw clear conclusions regarding what underlying mechanisms (such as change in underlying associations) *cause* those changes in eating attitudes. Indeed, is it entirely possible that different groups of women may experience benefits from the program in different ways, just as women of different sexual orientations may experience eating disorder risks in different ways (Davids and Green, 2011; Alvy, 2013; Huxley et al., 2015; Watson et al., 2015).

We note a particular caveat relating to this non-straight sample in our study, however. Our overall sample size was hampered by difficulties some participants experienced with the IAT task, and we had poorer completion in the control condition. As regards non-heterosexual participants, we were unable to further subdivide our participants into sexual orientation groups as there was insufficient representation of participants across the Kinsey scale to effectively split into bisexual and lesbian. Furthermore, as sexual orientation scores were unevenly spread between the control and intervention conditions, we were unable to form any comparable non-heterosexual control group. This is a clear limitation and future research would benefit from recruiting participants in larger numbers (we were largely limited by recruitment through just three LGBTa+ societies).

We also did not address the broader range of sexualities (e.g., a- and demi-sexual, and "pansexual," "heteroflexible," "queer"; Callis, 2014). Given that these groups may all differ in key respects (e.g., Chmielewski and Yost, 2013; Smalley et al., 2016) and some studies have found that some sexual orientation subgroups may be more at risk than others (e.g., "pan": Himmelstein et al., 2019; or "unsure": Diemer et al., 2015), further research should consider the impact of sexual orientation on eating disorder interventions in more detail. We also note that we have concentrated on sexual orientation in women but that sexual orientation is also important in body image and eating pathology in men (as discussed above, a similar intervention has been adapted for gay men: see Brown and Keel, 2015; Jankowski et al., 2017) and that gender identity may also be an important factor to consider. Trans individuals may have particularly high risk of pathological eating attitudes and/or unhealthy weight control behaviors (e.g., Diemer et al., 2015; Brewster et al., 2019) and may particularly benefit from targeted intervention work.

We further note that we used only the EAT-26 as our explicit measure of attitude changes over time, and not other measures such as those explicitly addressing body esteem (both positive and negative) and thin-ideal internalization. Our implicit measure likewise only addressed whether participants associated slimmer figures with positive social attributes, and did not address their own self-concept or associations with food. We would therefore suggest further research not only replicating the current results but also broadening the scope of which aspects of implicit cognitions relating to body esteem and eating disorders are considered. Other forms of implicit attitudes may also be worthy of investigation, such as the Implicit Relational Assessment Procedure (IRAP) which is similar to the IAT; yet it adds relational components to assess directionality and relations between concepts, and was used by Timko et al. (2010) to assess implicit body image dissatisfaction.

In conclusion, we have demonstrated that an immersive, intensive dissonance-based body image intervention may be able to impact implicit attitudes *via* associative response latencies among predominantly heterosexual women, while non-heterosexual women experienced benefits in explicit eating attitudes but no significant change in thin-bias. Further research, however, is badly needed to confirm these results and further establish (1) the extent to which implicit attitude change may be seen across related associations and over time and (2) how sexual orientation or identity moderates the effects in women.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/**Supplementary Material**.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Durham University Psychology Department Ethics Committee. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors contributed to study design. ES programmed test materials. RK and AW-C collected the data. LB performed data analyses. RK and LB wrote the manuscript with input from all authors.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02611/full#supplementary-material

DATA SHEET S1 | Final data set.

DATA SHEET S2 | Supplementary material and code.

REFERENCES

Alvy, L. M. (2013). Do lesbian women have a better body image? Comparisons with heterosexual women and model of lesbian-specific factors. *Body Image* 10, 524–534. doi: 10.1016/j.bodyim.2013.06.002

Antfolk, J., Ålgars, M., Holmgård, L., and Santtila, P. (2017). Body dissatisfaction and disordered eating in androphilic and gynephilic men and women. *Personal. Individ. Differ.* 117, 6–10. doi: 10.1016/j.paid.2017.05.027

Austin, S. B. (2016). Accelerating progress in eating disorders prevention: a call for policy translation research and training. *Eat. Disord.* 24, 6–19. doi: 10.1080/10640266.2015.1034056

Austin, S. B., Nelson, L. A., Birkett, M. A., Calzo, J. P., and Everett, B. (2013). Eating disorder symptoms and obesity at the intersections of gender, ethnicity, and sexual orientation in US high school students. *Am. J. Public Health* 103, e16–e22. doi: 10.2105/AJPH.2012.301150

Austin, S. B., Ziyadeh, N. J., Corliss, H. L., Rosario, M., Wypij, D., Haines, J., et al. (2009). Sexual orientation disparities in purging and binge eating from early to late adolescence. *J. Adolesc. Health* 45, 238–245. doi: 10.1016/j.jadohealth.2009.02.001

Becker, C. B., Smith, L. M., and Ciao, A. C. (2005). Reducing eating disorder risk factors in sorority members: a randomized trial. *Behav. Ther.* 36, 245–253. doi: 10.1016/S0005-7894(05)80073-5

Becker, C. B., and Stice, E. (2011). *Succeed, body image programme manual.* Oxford: Oxford University Press.

Becker, C. B., and Stice, E. (2012). *Reflections: Body image program-facilitator guide*. Oxford: Oxford University Press.

Berends, T., Boonstra, N., and van Elburg, A. (2018). Relapse in anorexia nervosa: a systematic review and meta-analysis. *Curr. Opin. Psychiatry* 31, 445–455. doi: 10.1097/YCO.0000000000000453

Boothroyd, L. G., Tovée, M. J., and Pollet, T. V. (2012). Visual diet versus associative learning as mechanisms of change in body size preferences. *PLoS One* 7:e48691. doi: 10.1371/journal.pone.0048691

Brewster, M. E., Velez, B. L., Breslow, A. S., and Geiger, E. F. (2019). Unpacking body image concerns and disordered eating for transgender women: the roles of sexual objectification and minority stress. *J. Couns. Psychol.* 66, 131–142. doi: 10.1037/cou0000333

Brown, T. A., and Keel, P. K. (2015). A randomized controlled trial of a peer co-led dissonance-based eating disorder prevention program for gay men. *Behav. Res. Ther.* 74, 1–10. doi: 10.1016/j.brat.2015.08.008

Callis, A. S. (2014). Bisexual, pansexual, queer: non-binary identities and the sexual borderlands. *Sexualities* 17, 63–80. doi: 10.1177/1363460713511094

Cash, T. F., and Smolak, L. (eds.) (2011). *Body image: A handbook of science, practice, and prevention*: Guilford Press.

Chmielewski, J. F., and Yost, M. R. (2013). Psychosocial influences on bisexual women's body image: negotiating gender and sexuality. *Psychol. Women Q.* 37, 224–241. doi: 10.1177/0361684311426126

Davids, C. M., and Green, M. A. (2011). A preliminary investigation of body dissatisfaction and eating disorder symptomatology with bisexual individuals. *Sex Roles* 65:533. doi: 10.1007/s11199-011-9963-y

DeJong, H., Broadbent, H., and Schmidt, U. (2012). A systematic review of dropout from treatment in outpatients with anorexia nervosa. *Int. J. Eat. Disord.* 45, 635–647. doi: 10.1002/eat.20956

Diemer, E. W., Grant, J. D., Munn-Chernoff, M. A., Patterson, D. A., and Duncan, A. E. (2015). Gender identity, sexual orientation, and eating-related pathology in a national sample of college students. *J. Adolesc. Health* 57, 144–149. doi: 10.1016/j.jadohealth.2015.03.003

Ebert, I. D., Steffens, M. C., Von Stülpnagel, R., and Jelenec, P. (2009). How to like yourself better, or chocolate less: changing implicit attitudes with one IAT task. *J. Exp. Soc. Psychol.* 45, 1098–1104. doi: 10.1016/j.jesp.2009.06.008

Garner, D. M., Olmsted, M. P., Bohr, Y., and Garfinkel, P. E. (1982). The eating attitudes test: psychometric features and clinical correlates. *Psychol. Med.* 12, 871–887. doi: 10.1017/S0033291700049163

Gawronski, B., and Bodenhausen, G. V. (2006). Associative and propositional processes in evaluation: an integrative review of implicit and explicit attitude change. *Psychol. Bull.* 132, 692–731. doi: 10.1037/0033-2909.132.5.692

Gawronski, B., and LeBel, E. P. (2008). Understanding patterns of attitude change: when implicit measures show change, but explicit measures do not. *J. Exp. Soc. Psychol.* 44, 1355–1361. doi: 10.1016/j.jesp.2008.04.005

Gawronski, B., LeBel, E. P., and Peters, K. R. (2007). What do implicit measures tell us?: scrutinizing the validity of three common assumptions. *Perspect. Psychol. Sci.* 2, 181–193. doi: 10.1111/j.1745-6916.2007.00036.x

Gawronski, B., and Strack, F. (2004). On the propositional nature of cognitive consistency: dissonance changes explicit, but not implicit attitudes. *J. Exp. Soc. Psychol.* 40, 535–542. doi: 10.1016/j.jesp.2003.10.005

Greenwald, A. G., McGhee, D. E., and Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the implicit association test. *J. Pers. Soc. Psychol.* 74, 1464–1480. doi: 10.1037/0022-3514.74.6.1464

Grumm, M., Nestler, S., and Von Collani, G. (2009). Changing explicit and implicit attitudes: the case of self-esteem. *J. Exp. Soc. Psychol.* 45, 327–335. doi: 10.1016/j.jesp.2008.10.006

Harris, E. C., and Barraclough, B. (1998). Excess mortality of mental disorder. *Br. J. Psychiatry* 173, 11–53. doi: 10.1192/bjp.173.1.11

Himmelstein, M. S., Puhl, R. M., and Watson, R. J. (2019). Weight-based victimization, eating behaviors, and weight-related health in sexual and gender minority adolescents. *Appetite* 141:104321. doi: 10.1016/j.appet.2019.104321

Hofmann, W., Gawronski, B., Gschwendner, T., Le, H., and Schmitt, M. (2005). A meta-analysis on the correlation between the implicit association test and explicit self-report measures. *Personal. Soc. Psychol. Bull.* 31, 1369–1385. doi: 10.1177/0146167205275613

Huxley, C. J., Halliwell, E., and Clarke, V. (2015). An examination of the tripartite influence model of body image: does women's sexual identity make a difference? *Psychol. Women Q.* 39, 337–348. doi: 10.1177/0361684314554917

Jankowski, G. S., Diedrichs, P. C., Atkinson, M. J., Fawkner, H., Gough, B., and Halliwell, E. (2017). A pilot controlled trial of a cognitive dissonance-based body dissatisfaction intervention with young British men. *Body Image* 23, 93–102. doi: 10.1016/j.bodyim.2017.08.006

Keshaviah, A., Edkins, K., Hastings, E. R., Krishna, M., Franko, D. L., Herzog, D. B., et al. (2014). Re-examining premature mortality in anorexia nervosa: a meta-analysis redux. *Compr. Psychiatry* 55, 1773–1784. doi: 10.1016/j.comppsych.2014.07.017

Kilpela, L. S., Hill, K., Kelly, M. C., Elmquist, J., Ottoson, P., Keith, D., et al. (2014). Reducing eating disorder risk factors: a controlled investigation of a blended task-shifting/train-the-trainer approach to dissemination and implementation. *Behav. Res. Ther.* 63, 70–82.

Kinsey, A. C., Pomeroy, W. B., and Martin, C. E. (1948). *Sexual behaviour in the human male*. Philadelphia: W.B. Saunders.

Matthews-Ewald, M. R., Zullig, K. J., and Ward, R. M. (2014). Sexual orientation and disordered eating behaviors among self-identified male and female college students. *Eat. Behav.* 15, 441–444. doi: 10.1016/j.eatbeh.2014.05.002

Morrison, M. A., Morrison, T. G., and Sager, C. L. (2004). Does body satisfaction differ between gay men and lesbian women and heterosexual men and women?: a meta-analytic review. *Body Image* 1, 127–138. doi: 10.1016/j.bodyim.2004.01.002

Olmsted, M. P., MacDonald, D. E., McFarlane, T., Trottier, K., and Colton, P. (2015). Predictors of rapid relapse in bulimia nervosa. *Int. J. Eat. Disord.* 48, 337–340. doi: 10.1002/eat.22380

Owens, L. K., Hughes, T. L., and Owens-Nicholson, D. (2002). The effects of sexual orientation on body image and attitudes about eating and weight. *J. Lesbian Stud.* 7, 15–33. doi: 10.1300/J155v07n01_02

Pennesi, J. L., and Wade, T. D. (2016). A systematic review of the existing models of disordered eating: Do they inform the development of effective interventions? *Clin. Psychol. Rev.* 43, 175–192.

Peplau, L. A., Frederick, D. A., Yee, C., Maisel, N., Lever, J., and Ghavami, N. (2009). Body image satisfaction in heterosexual, gay, and lesbian adults. *Arch. Sex. Behav.* 38, 713–725. doi: 10.1007/s10508-008-9378-1

Polimeni, A. M., Austin, S. B., and Kavanagh, A. M. (2009). Sexual orientation and weight, body image, and weight control practices among young Australian women. *J. Women's Health* 18, 355–362. doi: 10.1089/jwh.2007.0765

Smalley, K. B., Warren, J. C., and Barefoot, K. N. (2016). Differences in health risk behaviors across understudied LGBT subgroups. *Health Psychol.* 35, 103–114. doi: 10.1037/hea0000231

Stice, E. (2002). Risk and maintenance factors for eating pathology: a meta-analytic review. *Psychol. Bull.* 128, 825–848. doi: 10.1037/0033-2909.128.5.825

Stice, E., and Bearman, S. K. (2001). Body-image and eating disturbances prospectively predict increases in depressive symptoms in adolescent girls: a growth curve analysis. *Dev. Psychol.* 37, 597–607. doi: 10.1037/0012-1649.37.5.597

Stice, E., Marti, C. N., and Rohde, P. (2013). Prevalence, incidence, impairment, and course of the proposed DSM-5 eating disorder diagnoses in an 8-year prospective community study of young women. *J. Abnorm. Psychol.* 122, 445–457. doi: 10.1037/a0030679

Stice, E., Marti, C. N., Shaw, H., and Rohde, P. (2019). Meta-analytic review of dissonance-based eating disorder prevention programs: intervention, participant, and facilitator features that predict larger effects. *Clin. Psychol. Rev.* 70, 91–107. doi: 10.1016/j.cpr.2019.04.004

Stice, E., Marti, C. N., Spoor, S., Presnell, K., and Shaw, H. (2008). Dissonance and healthy weight eating disorder prevention programs: long-term effects from a randomized efficacy trial. *J. Consult. Clin. Psychol.* 76, 329–340. doi: 10.1037/0022-006X.76.2.329

Stice, E., Ng, J., and Shaw, H. (2010). Risk factors and prodromal eating pathology. *J. Child Psychol. Psychiatry* 51, 518–525. doi: 10.1111/j.1469-7610.2010.02212.x

Stice, E., and Shaw, H. (2004). Eating disorder prevention programs: a meta-analytic review. *Psychol. Bull.* 130, 206–227. doi: 10.1037/0033-2909.130.2.206

Stice, E., Yokum, S., and Waters, A. (2015). Dissonance-based eating disorder prevention program reduces reward region response to thin models; how actions shape valuation. *PLoS One* 10:e0144530. doi: 10.1371/journal.pone.0144530

Strong, S. M., Williamson, D. A., Netemeyer, R. G., and Geer, J. H. (2000). Eating disorder symptoms and concerns about body differ as a function of gender and sexual orientation. *J. Soc. Clin. Psychol.* 19, 240–255. doi: 10.1521/jscp.2000.19.2.240

Tiggemann, M., and Miller, J. (2010). The internet and adolescent girls' weight satisfaction and drive for thinness. *Sex Roles* 63, 79–90. doi: 10.1007/s11199-010-9789-z

Timko, C. A., England, E. L., Herbert, J. D., and Forman, E. M. (2010). The implicit relational assessment procedure as a measure of self-esteem. *Psychol. Rec.* 60, 679–698. doi: 10.1007/BF03395739

Vall, E., and Wade, T. D. (2015). Predictors of treatment outcome in individuals with eating disorders: a systematic review and meta-analysis. *Int. J. Eat. Disord.* 48, 946–971. doi: 10.1002/eat.22411

Watson, R. J., Adjei, J., Saewyc, E., Homma, Y., and Goodenow, C. (2017). Trends and disparities in disordered eating among heterosexual and sexual minority adolescents. *Int. J. Eat. Disord.* 50, 22–31. doi: 10.1002/eat.22576

Watson, L. B., Grotewiel, M., Farrell, M., Marshik, J., and Schneider, M. (2015). Experiences of sexual objectification, minority stress, and disordered eating among sexual minority women. *Psychol. Women Q.* 39, 458–470. doi: 10.1177/0361684315575024

Watson, H. J., Joyce, T., French, E., Willan, V., Kane, R. T., Tanner-Smith, E. E., et al. (2016). Prevention of eating disorders: a systematic review of randomized, controlled trials. *Int. J. Eat. Disord.* 49, 833–862. doi: 10.1002/eat.22577

Wilson, T. D., Lindsey, S., and Schooler, T. Y. (2000). A model of dual attitudes. *Psychol. Rev.* 107, 101–126. doi: 10.1037/0033-295X.107.1.101

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Corrigendum: The Impact of a Dissonance-Based Eating Disorders Intervention on Implicit Attitudes to Thinness in Women of Diverse Sexual Orientations

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A Corrigendum on

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In the published article, there was an error in the Supplementary Data Sheet S1 as published. The original supplementary data included information which created a small risk of participant re-identification. This data has now been replaced with a fully anonymized file.

The authors apologize for this error and state that this does not change the analyzed variables or scientific conclusions of the article in any way. The original article has been updated.

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Risk Factors for Facial Appearance Dissatisfaction Among Orthognathic Patients: Comparing Patients to a Non-Surgical Sample

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This study conducted a cross-sectional investigation of facial appearance dissatisfaction between patients before undergoing orthognathic surgery and a non-surgical sample to evaluate the potential influencing factors of facial appearance dissatisfaction. A sample of 354 participants completed a set of questionnaires concerning facial appearance dissatisfaction, interpersonal pressure, media pressure, and fear of negative appearance evaluation (112 patients, 242 controls). The patients reported higher facial appearance dissatisfaction, more media pressure, more interpersonal pressure, and a greater fear of negative appearance evaluation among others than the control group. Moreover, regression analyses identified interpersonal pressure and fear of negative appearance evaluation as the main predictors of facial appearance dissatisfaction whether in the orthognathic patients or the control groups. The associations between the perceptions of interpersonal pressure, fear of negative appearance evaluation, and facial appearance dissatisfaction support the possible utility of strengthening social experiences and psychological intervention in preventing and treating these appearance-concerns, especially for the orthognathic patients.

Keywords: facial appearance dissatisfaction, orthognathic patients, media pressure, interpersonal pressure, fear of negative appearance evaluation

INTRODUCTION

Individuals' satisfaction with their appearance is of central importance to their psychological well-being and health. Previous research has demonstrated negative associations between appearance satisfaction and depression, social avoidance, and low quality of life, both within the general population (Wilson et al., 2013; Griffiths et al., 2017) and among clinical samples with dentofacial deformities who are thought to be particularly vulnerable to dissatisfaction with their facial appearance (Frejman et al., 2013; Feragen and Stock, 2016, 2017). Epidemiological surveys show that about 40% of the population has malocclusion, about 5% of which is due to abnormal skeletal malformation caused by abnormal jaw development, i.e., dentofacial deformity (Qiu, 2008). Dentofacial deformities are changes or irregularities that primarily affect the jaws and teeth. However, multiple craniofacial structures may also be affected (Ong, 2004).

In most cases, they are the result of moderate or severe genetic distortions that occurred during the normal development process (such as mandibular prognathism, bimaxillary prognathism or retrognathism, and maxillary vertical excess) and can be corrected using an integrated treatment of orthodontics and orthognathic surgery in adults (Leite et al., 2004).

Facial attractiveness is highly valued in modern society and plays a central role in social activities, such as choosing a partner (Morgan and Kisley, 2014). However, dentofacial deformities cause facial attractiveness to deviate from the sociocultural norms of beauty and attractiveness. This often causes people with dentofacial deformities to feel that they are different from their peers in terms of facial appearance and to suffer from facial appearance dissatisfaction, which may lead to other psychosocial problems such as feelings of hopelessness, interpersonal problems, and low self-esteem (Cadogan and Bennun, 2011; Alanko et al., 2014; Gomes et al., 2019). It has been reported that orthognathic patients have a better personal facial appearance evaluation after orthognathic surgery than before, and their social functioning and self-confidence have improved. These patients also exhibit positive life changes and reduced anxiety (Soh and Narayanan, 2014; Al-Asfour et al., 2018). Although satisfaction with orthognathic treatment is generally high, a small but important group of patients is dissatisfied with the outcome, often despite technically good results (Lee et al., 2007; Ryan et al., 2012). This phenomenon may be caused by psychological factors. Therefore, it is important to investigate psychological factors that may affect patients' satisfaction with treatment outcomes before offering orthognathic surgery treatment. Therefore, knowledge concerning the specific factors thought to affect the development of subjective facial appearance evaluations among orthognathic patients is essential.

Mass media represents a powerful source of perceived societal values and standards, especially concerning "ideal beauty," weight, food, and fashion (Levine and Harrison, 2009). An experimental study by Newton and Minhas (2005) demonstrated that female orthognathic patients display more dissatisfaction with their facial appearance after viewing idealized images of facial photographs than females who were not orthognathic patients. Some studies have illustrated that patients with dentofacial deformities perceived social pressure which is created by the media and its representation of "ideal beauty," but none of these studies have specifically addressed the impact of this pressure on the facial appearance satisfaction of orthognathic patients. Moreover, in the research field of body dissatisfaction, a large number of studies have shown that perceived media pressure can exacerbate an individual's body dissatisfaction (Robinson et al., 2017; Want and Saiphoo, 2017). Therefore, it is important to discover what the impact of perceived mass media pressure on orthognathic patients' facial appearance dissatisfaction is.

In addition to mass media, researchers have theorized that messages about appearance-related standards of beauty can also be transmitted by modeling and appearance-related feedback from family members, friends, and romantic partners (Schaefer and Salafia, 2014; Girard et al., 2018). In the field of body dissatisfaction, these messages are often transmitted covertly (e.g., a mother may project a certain message to her daughter about body weight and shape through her dieting habits) or overtly (e.g., a sibling calling their sibling "fat"). Both these messages increase interpersonal pressure for individuals to change their appearance (Chng and Fassnacht, 2016; Thogersen-Ntoumani et al., 2016). This illustrates how weight-related pressure and criticism serves to promote adherence to societal norms concerning weight and shape, further contributing to the individual's body dissatisfaction. Similarly, associations between interpersonal experiences and subjective appearance evaluations have been described in numerous cross-sectional and quantitative studies within the cleft lip and/or palate (CL/P) literature (Berger and Dalton, 2011; Searle et al., 2017). However, there are no studies comparing the perceived interpersonal pressure regarding facial appearance for people with and without dentofacial deformities. It is reasonable to speculate that due to their unusual facial appearance, orthognathic patients will perceive more interpersonal pressure than those without dentofacial deformities. Furthermore, interpersonal pressure can predict one's facial appearance dissatisfaction.

Generally, fear of negative evaluation (FNE) can be understood as a type of social anxiety or apprehension about being negatively judged by others and avoidance of situations in which these negative evaluations may occur (Watson and Friend, 1969). Few studies have found a negative correlation between FNE and satisfaction with the appearance in adults with a congenital craniofacial anomaly. Adults with a congenital craniofacial anomaly were more dissatisfied with their facial appearance when they reported an increased FNE (Versnel et al., 2010; Roberts and Mathias, 2013). Importantly, fear of negative appearance evaluation, a domain-specific FNE—which is defined as social anxiety and distress based on having one's appearance negatively evaluated (Hart et al., 2008)—may also be associated with facial appearance dissatisfaction. Claes et al. (2012) found that fear of negative appearance evaluation was positively correlated with body dissatisfaction in women diagnosed with an eating disorder. Besides, Levinson and Rodebaugh (2012) found that fear of negative appearance evaluation could predict an individual's body dissatisfaction. However, no research has yet focused on the impact of fear of negative appearance evaluation on facial appearance dissatisfaction.

In summary, psychological factors may play an important role in orthognathic patients' perception of their facial appearance. According to previous studies on body dissatisfaction, media pressure, interpersonal pressure, and fear of negative appearance evaluation may be the three psychological factors most likely to affect the facial appearance dissatisfaction of clinical patients with dentofacial deformities. However, the first limitation of current research is that no study has focused on the differences between orthognathic patients and a non-surgical sample without dentofacial deformities in facial appearance dissatisfaction, media pressure, interpersonal pressure, and fear of negative appearance evaluation. Moreover, there is limited research that has focused on the role of psychological influences on individuals' perception of facial appearance to seek better psychological interventions for improving orthognathic patients' satisfaction with orthognathic surgery treatment outcomes. The current study thus aimed to compare orthognathic patients (patients before undergoing orthognathic surgery) and a non-surgical sample (the controls) in the levels of facial appearance dissatisfaction, appearance pressure from interpersonal relationships and mass media, and negative appearance evaluation fears, as well as to investigate the predictors of facial appearance dissatisfaction among the two groups. In line with previous findings, we hypothesized that (1) the patients would have a higher level of facial appearance dissatisfaction than the controls. Furthermore, relative to the control sample, patients were expected to report more appearance pressure from interpersonal relationships and mass media, and greater negative appearance evaluation fears. We also hypothesized that (2) among the patients and control groups, media pressure, interpersonal pressure, and fear of negative appearance evaluation would be predictors of facial appearance dissatisfaction, and the predictive effect was more significant in patients' facial appearance dissatisfaction.

METHODS

Participants

The initial sample consisted of 381 participants (136 patients and 245 controls). Twenty-seven participants (7.09%) were excluded from the sample for being younger than 18 years of age. The final sample consisted of 354 participants [patients: 112 (31.64%), controls: 242 (68.36%)], ranging from 18 to 35 years of age (M = 20.78 years, SD = 3.04 years). The patient sample included 112 individuals (females: 76 males: 36) and their ages ranged from 18 to 35 (M = 22.79 years, SD = 4.20 years). The patients' inclusion criteria were: adult patients (more than 18 years old), the presence of skeletal deformity affecting patients' appearance, is scheduled to undergo orthognathic surgery. The patients' exclusion criteria were: trauma or previous orthognathic surgery, syndromic patients, cleft lip and palate patients, distraction osteogenesis cases, and patients who had undergone isolated genioplasty procedures. The control group consisted of 242 college students (females: 163, males: 79) who did not have any facial skeletal discrepancies. Additionally, these individuals were not orthodontic patients. Their ages ranged from 18 to 27 years (M = 19.85, SD = 1.63). All the participants were from mainland China. Similar to the ethnic group composition of the general population, the great majority of the participants (80.20%) was Han (national minorities: 19.80%). There were no gender differences between the patients and controls, χ^2 (1) = 0.01, p = 0.93. Furthermore, there was a significant difference in age between the two groups; $t(155) = 7.14$, $p < 0.001$.

Procedure

This study was approved by the ethics committee for human research at Southwest University. A doctor's assistant from the Stomatological Hospital of Chongqing Medical University was instructed thoroughly concerning the study and contacted the orthognathic patients from the Stomatological Hospital of Chongqing Medical University. The patients would receive a survey packet that included a brief research overview, an informed consent agreement, and self-report measures described below. The patients were asked to complete a set of questionnaires carefully. The patient completed the questionnaire 2 days before the surgery. The controls were college students from Zunyi Medical College who did not undergo orthognathic surgery, completed the questionnaires in school hours. This study was carried out from December 2015 to February 2017.

All measures and questionnaires of this study were in Chinese. Several scales (the Sociocultural Attitudes Toward Appearance Scale-3, the Perceived Sociocultural Pressure Scale, and Fear of Negative Appearance Evaluation) were translated into Chinese and back-translated into English in previously published works (e.g., Jackson and Chen, 2010, 2011; Chen and Jackson, 2012). The Negative Physical Self-Face Scale has had a Chinese vision (see Chen et al., 2006).

Measures

Demographic Variables

Participants were asked to provide their age, gender, income levels, relationship status, and nation information.

Facial Appearance Dissatisfaction

Facial appearance dissatisfaction was assessed using the Facial Appearance Concern subscale of the Negative Physical Self Scale (NPSS; Chinese version: Chen et al., 2006; Chen and Jackson, 2007). The Facial Appearance Concern subscale consists of 11 items and is comprised of three sub-dimensions: cognition-affect (e.g., "I am depressed about how my face looks"), behavior (e.g., "If it is possible, I will change the way my face looks"), and projection (e.g., "People around me do not like the way my face looks"). All items were rated on a 5-point scale ranging from 0 (never) to 4 (always). Items were averaged to form a total score, with higher scores indicating more facial appearance dissatisfaction. The Facial Appearance Concern subscale has a stable factor structure as well as good reliability and validity among Chinese samples (Chen et al., 2006; Jackson and Chen, 2008; Wang et al., 2019). For the current study, the Cronbach's alpha values were 0.91 among the patients and 0.90 among the controls.

Media Pressure

Reported appearance pressure from mass media was calculated by adding the eight items from the Pressure subscale of the Sociocultural Attitudes Toward Appearance Scale-3 (*SATAQ-3*; Thompson et al., 2004; Chinese version: Chen and Jackson, 2012). Each statement was assessed on a Likert-type scale that ranged from 1 (*totally disagree*) to 5 (*totally agree*). An example item is "I have felt pressure from TV or magazines to change my appearance." However, four items about thinness (e.g., "I have felt pressure from TV and magazines to be thin") were removed, as they are not relevant to the research theme. The final score was calculated by the sum of the responses, with higher scores indicating more media pressure. The subscale has satisfactory reliability and validity in Chinese samples (Chen and Jackson, 2012). The Cronbach's alpha values of the 4-item version of the subscale for the present study sample were 0.91 among patients and 0.81 among the controls.

Interpersonal Pressure

Six items of the Perceived Sociocultural Pressure Scale-Interpersonal (*PSPS-I*; Stice and Agras, 1998; Chinese version: Jackson and Chen, 2008) were used to assess appearance pressure from friends (e.g., "I have felt pressure from my friends to change my physical appearance"), family (e.g., "I have felt pressure from my family to change my physical appearance") and prospective romantic partner ("I have felt pressure from people that I am interested in dating to change my physical appearance"). Each item was rated from 1 (*none*) to 5 (*a lot*). For the Chinese samples, items have been modified slightly to reflect pressure to "change my physical appearance" or "have a certain physical appearance" rather than pressure to be thin (e.g., Jackson and Chen, 2008). Concerning the "romantic partner" items, these were changed to include the respondent's "current romantic partner or people I would like to date" to increase applicability to all respondents, including those not currently dating. The final score was calculated by the sum of the responses, with higher scores indicating more interpersonal pressure. Chen and Jackson (2012) found all six interpersonal PSPS items loaded on one component in Chinese samples of each gender. The Cronbach's alpha values for this variable were 0.86 for patients and 0.79 for the controls.

Fear of Negative Appearance Evaluation

The six-item fear of negative appearance evaluation (*FNAE*, Lundgren et al., 2004; Chinese version: Jackson and Chen, 2011) assessed the frequency of concerns that others will judge one's physical appearance negatively. Sample items included "I worry that people will find fault with the way I look" and "I am afraid other people will notice my physical flaws." Each item was rated from 1 (*never*) to 5 (*almost always true*). The final score was calculated by the sum of the responses, with higher scores indicating a greater FNAE. The questionnaire showed good reliability for Chinese adolescents (Jackson and Chen, 2011). The Cronbach's alpha values were 0.90 for patients and 0.84 for controls.

Statistical Analyses

The statistical analyses were performed using SPSS 22. Descriptive analyses were conducted to obtain the ranges, means, and standard deviations of the two study groups (**Table 1**). Next, we performed a multivariate analysis of covariance (MANCOVA) controlling for age (covariates) between the patients and the controls for there was a significant difference in age between the two groups. To explore the relationships among facial appearance dissatisfaction, and risk factors (media pressure, interpersonal pressure, and fear of negative appearance evaluation), the correlations among the variables were initially examined in patients and controls separately by using a Pearson correlation (**Table 2**). We used a recommended guideline by Gignac and Szodorai (2016) for interpreting the magnitude of correlations (0.15 = small, 0.25 = medium, and 0.35 = large). Hierarchical multiple regression analyses were also conducted to determine the contribution of the variables of interest on facial appearance dissatisfaction, controlling the model with the age and gender of the patients and controls separately (**Table 3**). Multicollinearity was examined using tolerance and VIF statistics and found to be acceptable in all cases. Highest VIF values were 2.26, and lowest tolerance values were 0.44.

RESULTS

Between-Group Differences in Facial Appearance Dissatisfaction, Risk Factors

Table 1 presents the scale range, mean values, and standard deviations (SD) of the study variables among the orthognathic patients and the control group.

In accordance with our first research question, the multivariate analysis of covariance revealed significant differences in the combined variables, F (4, 347) = 9.13, $p < 0.001$, $\eta^2 = 0.10$; Pillai's trace = 0.10. An examination of the univariate values of F indicated that compared to the control group, the patients reported higher facial appearance dissatisfaction, more media pressure, more interpersonal pressure, and a greater fear of negative appearance evaluation among others (**Table 1**).

Predictors of Facial Appearance Dissatisfaction

The bivariate correlations among all the study variables for both samples are presented in **Table 2**. For both the patients

TABLE 1 | Scale range, mean, and standard deviation (SD) for study variables among orthognathic patients and the control group.

Measures	Participants (*N* = 354)				*Fdf* (1, 350)	η^2
	Patients (*N* = 112)		Controls (*N* = 242)			
	Range	*M* ± SD	Range	*M* ± SD		
Facial appearance dissatisfaction	0.27–3.73	1.60 ± 0.73	0–3.73	1.08 ± 0.70	32.83***	0.09
Media pressure	4–20	10.29 ± 3.99	4–20	8.89 ± 3.39	9.66**	0.03
Interpersonal pressure	6–26	13.64 ± 4.81	6–27	11.91 ± 4.23	8.34**	0.02
Fear of negative appearance Evaluation	7–30	17.99 ± 5.38	6–30	14.91 ± 4.65	26.10***	0.07

***p < 0.01; ***p < 0.001.*

TABLE 2 | Correlations between studied variables for orthognathic patients and the control group.

Variables	1	2	3	4	5	6
1. Age	—	—	−0.02	0.01	−0.04	−0.05
2. Gender	—	—	0.03	−0.02	0.07	−0.06
3. Facial appearance dissatisfaction	**0.12**	**0.02**	**—**	0.39**	0.43**	0.60**
4. Media pressure	**−0.02**	**−0.06**	**0.44****	**—**	0.65**	0.51**
5. Interpersonal pressure	**0.06**	**−0.01**	**0.52****	**0.69****	—	0.45**
6. Fear of negative appearance evaluation	**−0.01**	**−0.002**	**0.67****	**0.57****	**0.53****	**—**

$^{**}p < 0.01$.
*Values for orthognathic patients are in **bold**; values for the controls are in not bold.*

and control groups, the pattern of correlations confirmed the expected relationships between the study variables. Furthermore, the findings concerning the bivariate correlations reveal that in both samples, facial appearance dissatisfaction has a strong association with media pressure (patients: $r = 0.44$, $p < 0.01$; controls: $r = 0.39$, $p < 0.01$), interpersonal pressure (patients: $r = 0.52$, $p < 0.01$; controls: $r = 0.43$, $p < 0.01$), and fear of negative appearance evaluation (patients: $r = 0.67$, $p < 0.01$; controls: $r = 0.60$, $p < 0.01$).

Starting with these significant associations, we conducted hierarchical multiple regression analyses with facial appearance dissatisfaction as a dependent variable (**Table 3**). We also proposed independent models for patients and the controls. Because previous analyses revealed age- and gender-related variations in body dissatisfaction (Menzel et al., 2010; Chng and Fassnacht, 2016), to exclude the influence of irrelevant variables in this study, we accounted for the baseline level of these demographic variables in the first step.

For the orthognathic patients, after the age and gender analyses, the predictors explained 50% of the variance in facial appearance dissatisfaction changes (**Table 3**). The significant predictors were interpersonal pressure ($\beta = 0.29$, $p < 0.01$) and fear of negative appearance evaluation ($\beta = 0.58$, $p < 0.001$). Moreover, fear of negative appearance evaluation was the strongest predictor of facial appearance dissatisfaction for orthognathic patients. In this model, media pressure had no significant influence ($p > 0.05$).

Concerning the control group, the hypothesized predictors accounted for 39% of the variance in facial appearance dissatisfaction changes after controlling for age and gender (**Table 3**). The significant predictors were interpersonal pressure ($\beta = 0.19$, $p < 0.01$) and fear of negative appearance evaluation ($\beta = 0.51$, $p < 0.001$). Moreover, fear of negative appearance evaluation was considered to be the strongest predictor of facial appearance dissatisfaction, with media pressure again having no significant effect ($p > 0.05$).

In light of our original research question, these results suggest that while for both groups the results of hierarchical multiple regression analyses are the same, the associations between interpersonal pressure and fear of negative appearance evaluation and facial appearance dissatisfaction are stronger in orthognathic patients than in the control group (see **Table 3**).

DISCUSSION

This study is the first to investigate the relationship between psychological factors and facial appearance dissatisfaction when considering orthognathic patients and a non-surgical sample group. First, we determined the differences between the two groups concerning facial appearance dissatisfaction, media pressure, interpersonal pressure, and fear of negative appearance evaluation. Second, the findings contribute to our knowledge of interpersonal pressure and fear of negative appearance evaluation and their relationships with facial appearance dissatisfaction for both orthognathic patients and the control group.

The findings revealed that the orthognathic patients felt more dissatisfied with their facial appearance than the comparison groups. This is consistent with earlier research on the topic which has found patients who pursue orthognathic surgery were more concerned about their dentofacial appearance and general body image compared with the individuals who did not have skeletal discrepancies (Sar et al., 2015). Furthermore, the patients perceived more media pressure, interpersonal pressure, and reported greater fear of negative appearance evaluation than the controls. These findings are consistent with the patients' situation before orthognathic surgery. The patients feel that their dentofacial deformities make them look different from the peers and reduce their facial attractiveness, affecting many aspects of their lives, such as social interactions, their possible success when seeking employment, being chosen as a romantic partner, and not least, their personality and characteristics (Eslamipour et al., 2017). These differences between patients and the controls indicate that it is essential to investigate the risk factors concerning patients' facial appearance dissatisfaction and the related psychosocial factors, rather than only investigating the biological influence.

The predictive effects of the risk factors concerning facial appearance dissatisfaction in patients and controls were examined separately and the findings partially answered our research question. Generally, the patients and the controls showed the same pattern of results.

For both groups, interpersonal pressure reliably predicted concerns regarding facial appearance, suggesting that interpersonal pressure may have a negative influence on an individual's facial appearance satisfaction. This finding is consistent with similar research in body dissatisfaction literature, which presented that direct interpersonal influences can predict body dissatisfaction (Johnson et al., 2015). The interpersonal pressure may come from daily life communication overtly (e.g., appearance teasing from peers, parental comments regarding facial appearance) or covertly (e.g., parents worry that their children are disadvantaged in society because of facial appearance), and these pressures may profoundly affect the development and construction of individuals' facial appearance dissatisfaction.

The expected relationship between fear of negative appearance evaluation and facial appearance dissatisfaction was confirmed for both patients and controls. The result showed that fear of negative appearance evaluation was the most predictive variable on facial appearance dissatisfaction,

TABLE 3 | Hierarchical multiple regression analyses of risk factors predicting facial appearance dissatisfaction for orthognathic patients and the control group.

Predictors	Patients			Controls		
	SE	β	*t*	SE	β	*t*
Step1		$F_{change}(2,109) = 0.08$			$F_{change}(2,239) = 0.15$	
		$R^2_{change} = 0.001$			$R^2_{change} = 0.001$	
Age	0.07	0.01	0.20	0.52	0.01	0.10
Gender	0.15	0.02	0.35	0.11	0.04	0.83
Step2		$F_{change}(3,106) = 34.78$			$F_{change}(3,236) = 49.97$	
		$R^2_{change} = 0.50^{***}$			$R^2_{change} = 0.39^{***}$	
Media pressure	0.10	−0.11	−1.01	0.07	0.01	0.12
Interpersonal pressure	0.10	0.29	2.91**	0.07	0.19	2.69**
Fear of negative appearance evaluation	0.09	0.58	6.65***	0.06	0.51	8.50***

*All of the studied variables were mean-centered except for gender. **p < 0.01; ***p < 0.001.*

highlighting the centrality of this variable for facial appearance dissatisfaction. The observations in this study are consistent with that of Lundgren et al. (2004), who found that appearance evaluation fears predicted body image concerns. Similarly, Jackson and Chen (2011) found that fear of negative appearance evaluation was among the strongest predictors of changes in eating pathology for Chinese girls. Our results suggest that elevated fear of negative appearance evaluation may be a risk factor for the development of facial appearance dissatisfaction.

The lack of significance of the media in predicting facial appearance dissatisfaction among both patients and the non-surgical sample in this study is also of interest. There was a positive correlation between media pressure and facial appearance dissatisfaction for both groups. Contrary to our results, there is a substantial body of research that indicates that the media was the main source of influence on body dissatisfaction (Robinson et al., 2017; Want and Saiphoo, 2017). The sample size of orthognathic patients and non-clinical samples in this study is small, which may affect the statistical significance of media pressure. Another possible explanation is the difference in the findings may relate to mass media playing an important role in conveying body shape and weight ideals, rather than specifically facial features (e.g., Thompson et al., 1999; Thompson and Smolak, 2001). Contrary to body shape and weight ideals, there is no "gold standard" for facial beauty for the perceptions vary among various people (Rhodes, 2006), which may weaken the effect of media pressure. However, on the other hand, experimental research showed that exposure to idealized images of facial photographs transmitted by mass media can increase facial appearance dissatisfaction in female orthognathic patients (Newton and Minhas, 2005). There may be some discrepancies between the media pressure of self-report and the pressure caused by direct media exposure.

Limitations and Future Research Directions

A particular strength of this research is that we extended our research beyond body dimensions to facial characteristics to investigate the risk factors of facial appearance dissatisfaction among orthognathic patients and the controls. However, several limitations also need to be recognized. The first of these limitations is that it is not possible to conclude the direction of the relationship between the factors investigated due to the cross-sectional design of the study. Further clarification of these relationships requires studies using experimental or longitudinal designs. Second, a mismatch of the number of patients and the controls existed. Additional prospective research with larger clinical samples may be warranted. Third, this study lacks the representativeness of the clinical sample. It is difficult to apply the results to other clinical groups who typically undergo cosmetic surgery to alter specific facial features, such as "double-eyelids" and large eyes, a melon-shaped face, and small, proportionate, defined chin. Fourth, gender differences were found concerning shame regarding one's body and shape/weight concerns, revealing that women experience more body dissatisfaction than do men (Else-Quest et al., 2012; Buchanan et al., 2013). Lastly, we did not collect the educational level of all the subjects, which may affect the differences in the psychological factors between the two groups.

Although this study found the predictive effect of interpersonal pressure on facial appearance dissatisfaction, most existing studies focused on the impact of the specific aspects of interpersonal pressure on body dissatisfaction and have found evidence concerning the impact of different forms of interpersonal pressure, such as peer pressure and parental pressure (Helfert and Warschburger, 2011; Vries et al., 2015; Girard et al., 2018). Future research is needed to examine the effects of interpersonal pressure from family members, friends, and romantic partners on facial appearance dissatisfaction, and to clarify how an individual who is dissatisfied with oneself appearance to interpret and internalize these experiences. Moreover, as mentioned above, the media pressure of self-report and the pressure caused by direct media exposure on facial appearance dissatisfaction may have a different role. Future research is required to further clarify the precise mechanisms of media message to facial appearance dissatisfaction.

Clinical Implications

First, there were differences between patients and the controls concerning facial appearance dissatisfaction, media pressure, interpersonal pressure, and fear of negative appearance evaluation. These differences between the two groups indicate that the psychosocial factors for orthognathic patients are needed to be paid attention to before the surgical treatment.

Second, we found that facial appearance dissatisfaction was predicted by interpersonal pressure and fear of negative appearance evaluation in both orthognathic patients and non-patients groups. Furthermore, interpersonal pressure and fear of negative appearance evaluation were more strongly associated with facial appearance dissatisfaction for the orthognathic patients. These findings further stress the importance of an interdisciplinary team in building the doctor team, including psychologists when working with people with dentofacial deformities. Psychologists should use measurement to assess the orthognathic patients' psychological state, and use reasonable interventions to adjust the psychological problems caused by the disease. More specifically, given that the fear of negative appearance evaluation has the strongest influence for orthognathic patients in this study, the psychologists in the team should pay attention to the role of fear of negative appearance evaluations and work toward changing people's attitudes concerning the negative appearance feedback to improve their facial appearance satisfaction. We believe that the research presented here is a step toward understanding negative appearance evaluation fears as an important risk factor for facial appearance dissatisfaction. Future research can further explore the psychological interventions used to change the fear of negative facial appearance in patients with dentofacial deformities.

CONCLUSION

In conclusion, the findings of this study expand upon previous work in the field by exploring the effects of risk factors of facial appearance dissatisfaction in both orthognathic patients and non-surgical controls. Generally, the patients and the controls showed the same pattern of results. The results suggest that interpersonal pressure and fear of negative appearance evaluation play a crucial role in facial appearance dissatisfaction for orthognathic patients as well as the non-surgical sample. More significantly, the findings point to the possibility that interventions promoting facial appearance satisfaction could change people's attitudes toward appearance feedback from friends or family, especially for orthognathic patients. In building the doctor team, it is important to form an interdisciplinary team, including psychologists when working with people with dentofacial deformities. Although the focus of orthognathic surgery procedures is on correcting the morphological deformity, the assessment and treatment plan should also involve the psychosocial aspects of orthognathic patients.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

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

AUTHOR CONTRIBUTIONS

PS made substantial contributions to the interpretation of data. PS and YH designed the study and wrote the protocol. HK was responsible for data collection. TW revised the language. HC conducted literature searches and provided summaries of previous research studies. All authors gave final approval of the version to be published and agreed to be accountable for all aspects of the work.

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REFERENCES

Alanko, O. M. E., Svedströmoristo, A. L., Peltomäki, T., Kauko, T., and Tuomisto, M. T. (2014). Psychosocial well-being of prospective orthognathic-surgical patients. *Acta Odontol. Scand.* 72, 887–897. doi: 10.3109/00016357.2014.920107

Al-Asfour, A., Waheedi, M., and Koshy, S. (2018). Survey of patient experiences of orthognathic surgery: health-related quality of life and satisfaction. *Int. J. Oral Maxillofac. Surg.* 47, 726–731. doi: 10.1016/j.ijom.2017.12.010

Berger, Z. E., and Dalton, L. J. (2011). Coping with a cleft II: factors associated with psychosocial adjustment of adolescents with a cleft lip and palate and their parents. *Cleft Palate Craniofac. J.* 48, 82–90. doi: 10.1597/08-094

Buchanan, N. T., Bluestein, B. M., Nappa, A. C., Woods, K. C., and Depatie, M. M. (2013). Exploring gender differences in body image, eating pathology, and sexual harassment. *Body Image* 10, 352–360. doi: 10.1016/j.bodyim.2013.03.004

Cadogan, J., and Bennun, I. (2011). Face value: an exploration of the psychological impact of orthognathic surgery. *Br. J. Oral Maxillofac. Surg.* 49, 376–380. doi: 10.1016/j.bjoms.2010.07.006

Chen, H., and Jackson, T. (2007). Stability of body image concerns among Chinese adolescents: nine-month test-retest reliabilities of the negative physical self scale. *Percept. Mot. Skills* 105, 677–680. doi: 10.2466/PMS.105.6.677-680

Chen, H., and Jackson, T. (2012). Gender and age group differences in mass media and interpersonal influences on body dissatisfaction among Chinese adolescents. *Sex Roles* 66, 3–20. doi: 10.1007/s11199-011-0056-8

Chen, H., Jackson, T., and Huang, X. (2006). The negative physical self scale: initial development and validation in samples of Chinese adolescents and young adults. *Body Image* 3, 401–412. doi: 10.1016/j.bodyim.2006.07.005

Chng, S. C. W., and Fassnacht, D. B. (2016). Parental comments: relationship with gender, body dissatisfaction, and disordered eating in Asian young adults. *Body Image* 16, 93–99. doi: 10.1016/j.bodyim.2015.12.001

Claes, L., Hart, T. A., Smits, D., Van den Eynde, F., Mueller, A., and Mitchell, J. E. (2012). Validation of the social appearance anxiety scale in female eating disorder patients. *Eur. Eat. Disord. Rev.* 20, 406–409. doi: 10.1002/erv.1147

Else-Quest, N. M., Higgins, A., Allison, C., and Morton, L. C. (2012). Gender differences in self-conscious emotional experience: a meta-analysis. *Psychol. Bull.* 138, 947–981. doi: 10.1037/a0027930

Eslamipour, F., Najimi, A., Tadayonfard, A., and Azamian, Z. (2017). Impact of orthognathic surgery on quality of life in patients with dentofacial deformities. *Int. J. Dent.* 2017:4103905. doi: 10.1155/2017/4103905

Feragen, K. B., and Stock, N. M. (2016). A longitudinal study of 340 young people with or without a visible difference: the impact of teasing on self-perceptions of appearance and depressive symptoms. *Body Image* 16, 133–142. doi: 10.1016/j.bodyim.2016.01.003

Feragen, K. B., and Stock, N. M. (2017). Psychological adjustment to craniofacial conditions (excluding oral clefts): a review of the literature. *Psychol. Health* 32, 253–288. doi: 10.1080/08870446.2016.1247838

Frejman, M. W., Vargas, I. A., Rösing, C. K., and Closs, L. Q. (2013). Dentofacial deformities are associated with lower degrees of self-esteem and higher impact on oral health-related quality of life: results from an observational study involving adults. *J. Oral Maxillofac. Surg.* 71, 763–767. doi: 10.1016/j.joms.2012.08.011

Gignac, G. E., and Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personal. Individ. Differ.* 102, 74–78. doi: 10.1016/j.paid.2016.06.069

Girard, M., Rodgers, R. F., and Chabrol, H. (2018). Prospective predictors of body dissatisfaction, drive for thinness, and muscularity concerns among young women in France: a sociocultural model. *Body Image* 26, 103–110. doi: 10.1016/j.bodyim.2018.07.001

Gomes, A. M. D., Garbin, C. A. S., Ferraz, F. W. D., Saliba, T. A., and Garbin, A. J. I. (2019). Dentofacial deformities and implications on quality of life: a presurgical multifactorial analysis in patients seeking orthognathic surgical treatment. *J. Oral Maxillofac. Surg.* 77:409.e1. doi: 10.1016/j.joms.2018.09.023

Griffiths, S., Murray, S. B., Bentley, C., Gratwick-Sarll, K., Harrison, C., and Mond, J. M. (2017). Sex differences in quality of life impairment associated with body dissatisfaction in adolescents. *J. Adolesc. Health* 61, 77–82. doi: 10.1016/j.jadohealth.2017.01.016

Hart, T. A., Flora, D. B., Palyo, S. A., Fresco, D. M., Holle, C., and Heimberg, R. G. (2008). Development and examination of the social appearance anxiety scale. *Assessment* 15, 48–59. doi: 10.1177/1073191107306673

Helfert, S., and Warschburger, P. (2011). A prospective study on the impact of peer and parental pressure on body dissatisfaction in adolescent girls and boys. *Body Image* 8, 101–109. doi: 10.1016/j.bodyim.2011.01.004

Jackson, T., and Chen, H. (2008). Sociocultural influences on body image concerns of adolescent girls and young women from China. *Sex Roles* 58, 402–411. doi: 10.1007/s11199-007-9342-x

Jackson, T., and Chen, H. (2010). Sociocultural experiences of bulimic and non-bulimic adolescents in a school-based Chinese sample. *J. Abnorm. Child Psychol.* 38, 69–76. doi: 10.1007/s10802-009-9350-0

Jackson, T., and Chen, H. (2011). Risk factors for disordered eating during early and middle adolescence: prospective evidence from mainland Chinese boys and girls. *J. Abnorm. Psychol.* 120, 454–464. doi: 10.1037/a0022122

Johnson, S. M., Edwards, K. M., and Gidycz, C. A. (2015). Interpersonal weight-related pressure and disordered eating in college women: a test of an expanded tripartite influence model. *Sex Roles* 72, 15–24. doi: 10.1007/s11199-014-0442-0

Lee, L., Chen, S. H., Yu, C. C., Lo, L. J., Lee, S. R., and Chen, Y. R. (2007). Stigma, body image, and quality of life in women seeking orthognathic surgery. *Plast. Reconstr. Surg.* 120, 225–231. doi: 10.1097/01.prs.0000264100.57630.c7

Leite, P. C. C., Camarini, E. T., Iwaki Filho, L., Pavan, A. J., Farah, G. J., and da Silva, M. B. (2004). Estudo epidemiológico das deformidades dentofaciais de Maringá/PR-1997/2003. *Pesqui. Bras. Odontopediatr. Clin. Integr.* 4, 217–220.

Levine, M. P., and Harrison, K. (2009). "Media effects on body image and eating disorders" in *Media effects: Advances in theory and research*. eds. J. Bryant and M. B. Oliver. 3rd edition (New York: Routledge), 490–516.

Levinson, C. A., and Rodebaugh, T. L. (2012). Social anxiety and eating disorder comorbidity: the role of negative social evaluation fears. *Eat. Behav.* 13, 27–35. doi: 10.1016/j.eatbeh.2011.11.006

Lundgren, J. D., Anderson, D. A., and Thompson, J. K. (2004). Fear of negative appearance evaluation: development and evaluation of a new construct for risk factor work in the field of eating disorders. *Eat. Behav.* 5, 75–84. doi: 10.1016/S1471-0153(03)00055-2

Menzel, J. E., Schaefer, L. M., Burke, N. L., Mayhew, L. L., Brannick, M. T., and Thompson, J. K. (2010). Appearance-related teasing, body dissatisfaction, and disordered eating: a meta-analysis. *Body Image* 7, 261–270. doi: 10.1016/j.bodyim.2010.05.004

Morgan, L. K., and Kisley, M. A. (2014). The effects of facial attractiveness and perceiver's mate value on adaptive allocation of central processing resources. *Evol. Hum. Behav.* 35, 96–102. doi: 10.1016/j.evolhumbehav.2013.11.002

Newton, J. T., and Minhas, G. (2005). Exposure to 'ideal'facial images reduces facial satisfaction: an experimental study. *Community Dent. Oral Epidemiol.* 33, 410–418. doi: 10.1111/j.1600-0528.2005.00239.x

Ong, M. A. H. (2004). Spectrum of dentofacial deformities: a retrospective survey. *Ann. Acad. Med. Singap.* 33, 239–242. doi: 10.1080/13506120410001682569

Qiu, W. L. (2008). *Oral and maxillofacial surgery*. Shanghai, China: Shanghai Scientific and Technical Publishers.

Rhodes, G. (2006). The evolutionary psychology of facial beauty. *Annu. Rev. Psychol.* 57, 199–226. doi: 10.1146/annurev.psych.57.102904.190208

Roberts, R. M., and Mathias, J. L. (2013). Predictors of mental health in adults with congenital craniofacial conditions attending the Australian craniofacial unit. *Cleft Palate Craniofac. J.* 50, 414–423. doi: 10.1597/11-105

Robinson, L., Prichard, I., Nikolaidis, A., Drummond, C., Drummond, M., and Tiggemann, M. (2017). Idealised media images: the effect of fitspiration imagery on body satisfaction and exercise behaviour. *Body Image* 22, 65–71. doi: 10.1016/j.bodyim.2017.06.001

Ryan, F. S., Barnard, M., and Cunningham, S. J. (2012). What are orthognathic patients' expectations of treatment outcome-a qualitative study. *J. Oral Maxillofac. Surg.* 70, 2648–2655. doi: 10.1016/j.joms.2012.01.002

Sar, C., Soydan, S. S., Ozcirpici, A. A., and Uckan, S. (2015). Psychosocial and functional outcomes of orthognathic surgery: comparison with untreated controls. *J. Oral Maxillofac. Surg. Med. Pathol.* 27, 451–457. doi: 10.1016/j.ajoms.2014.03.001

Schaefer, M. K., and Salafia, E. H. B. (2014). The connection of teasing by parents, siblings, and peers with girls' body dissatisfaction and boys' drive for muscularity: the role of social comparison as a mediator. *Eat. Behav.* 15, 599–608. doi: 10.1016/j.eatbeh.2014.08.018

Searle, A., Neville, P., and Waylen, A. (2017). Psychological growth and well-being in individuals born with cleft: an application of self-determination theory. *Psychol. Health* 32, 459–482. doi: 10.1080/08870446.2016.1275630

Soh, C. L., and Narayanan, V. (2014). The impact of surgical correction on the quality of life in patients with dentofacial deformity—a prospective study. *J. Oral Maxillofac. Surg. Med. Pathol.* 27, 323–327. doi: 10.1016/j.ajoms.2014.03.003

Stice, E., and Agras, W. S. (1998). Predicting onset and cessation of bulimic behaviors during adolescence: a longitudinal grouping analysis. *Behav. Ther.* 29, 257–276. doi: 10.1016/S0005-7894(98)80006-3

Thogersen-Ntoumani, C., Ng, J. Y. Y., Ntoumanis, N., Chatzisarantis, N., Vlachopoulos, S., Katartzi, E. S., et al. (2016). 'Mum's the word': predictors and outcomes of weight concerns in pre-adolescent and early adolescent girls. *Body Image* 16, 107–112. doi: 10.1016/j.bodyim.2015.12.004

Thompson, J. K., Heinberg, L. J., Altabe, M., and Tantleff-Dunn, S. (1999). *Exacting beauty: Theory, assessment and treatment of body image disturbance*. Washington, DC: American Psychological Association.

Thompson, J. K., and Smolak, L. (2001). *Body image, eating disorders, and obesity in youth: Assessment, prevention, and treatment*. Washington, DC: American Psychological Association.

Thompson, J. K., van den Berg, P., Roehrig, M., Guarda, A. S., and Heinberg, L. J. (2004). The sociocultural attitudes towards appearance scale-3 (SATAQ-3): development and validation. *Int. J. Eat. Disord.* 35, 293–304. doi: 10.1002/eat.10257

Versnel, S. L., Duivenvoorden, H. J., Passchier, J., and Mathijssen, I. M. J. (2010). Satisfaction with facial appearance and its determinants in adults with severe congenital facial disfigurement: a case-referent study. *J. Plast. Reconstr. Aesthet. Surg.* 63, 1642–1649. doi: 10.1016/j.bjps.2009.10.018

Vries, D. A. D., Peter, J., Graaf, H. D., and Nikken, P. (2015). Adolescents' social network site use, peer appearance-related feedback, and body dissatisfaction: testing a mediation model. *J. Youth Adolesc.* 45, 211–224. doi: 10.1007/s10964-015-0266-4

Wang, Y., Fardouly, J., Vartanian, L. R., and Lei, L. (2019). Selfie-viewing and facial dissatisfaction among Chinese adolescents: a moderated mediation model of general attractiveness internalization and body appreciation. *Body Image* 30, 35–43. doi: 10.1016/j.bodyim.2019.05.001

Want, S. C., and Saiphoo, A. (2017). Social comparisons with media images are cognitively inefficient even for women who say they feel pressure from the media. *Body Image* 20, 1–6. doi: 10.1016/j.bodyim.2016.10.009

Watson, D., and Friend, R. (1969). Measurement of social-evaluative anxiety. *J. Consult. Clin. Psychol.* 33, 448–457. doi: 10.1037/h0027806

Wilson, R. E., Latner, J. D., and Hayashi, K. (2013). More than just body weight: the role of body image in psychological and physical functioning. *Body Image* 10, 644–647. doi: 10.1016/j.bodyim.2013.04.007

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Improvement of Body Satisfaction in Older People: An Experimental Study

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Aging typically manifests itself in a variety of physical and cognitive alterations and challenges that are not always easily accepted. Feeling dissatisfied with these changes can also affect the mood and self-esteem of older people causing body image problems. The present study focuses on body satisfaction in Spanish older people (176 participants; *M* and *SD* = 64.03 ± 1 8.06; age range 50 to over 75) by employing experimental research to test whether psychosocial interventions may have a positive impact. Our aims are threefold: (1) To describe the body satisfaction of older people considering intervening variables, such as age, gender, having a stable partner, time of the year, and place of residence; (2) to compare body satisfaction improvement in older people participating in a specific body satisfaction program designed for this purpose versus a non-specific program run by the Spanish Red Cross; and (3) to examine the relationship between age, gender, having a stable partner, time of the year, place of residence, body satisfaction and participating in the experimental condition. The *IMAGINA* specific body image program yielded a significant improvement in body satisfaction when compared with the non-specific program in both men and women regardless of marital status and in some age groups: 50 to 54 years old, 60 to 64 years old, and 65 to 69. Male participants, as well as singles, were more satisfied with their bodies, and the contrary was true for divorced and separated. The *IMAGINA* program was particularly useful in participants with more body image problems. As shown, the pressure to fit beauty standards and related problems do not go away with age, a fact that is embodied and experienced differently in men and women.

Keywords: body image, body satisfaction, older people, gender differences, body perception

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INTRODUCTION

The way we see our bodies influences how we feel about ourselves, and when our perceptions are negative, these can cause low self-esteem and mood problems. Body image could be defined as how a person sees, imagines, feels, and acts with his/her own body (Rosen, 1992; Thompson, 2004; Cash, 2017). We can distinguish two main elements: (1) a perceptive dimension that judges the size and proportions of one's own body, and (2) a cognitive-emotional dimension that is commonly known as body satisfaction (Raich, 2004; Sánchez-Cabrero and Maganto, 2009; Maganto et al., 2016).

In this paper, we focus on body satisfaction, i.e., the subjective image of one's own body in older people. This evaluation is regarded as unfavorable when it reduces personal confidence and makes someone feel bad about his/herself, and positive when it makes people feel good about themselves as well as comfortable when interacting with others (Tylka and Wood-Barcalow, 2015; Sánchez-Cabrero et al., 2019). Individuals in their fifties tend to experience body satisfaction problems as a result of bodily changes related to growing older (Hofmeier et al., 2017; Cameron et al., 2019). They particularly worry about aging signs such as wrinkles, hair loss, weakening of physical conditions, body odor, among others (Gubrium and Holstein, 2006; Longo, 2015; Vega et al., 2015). However, they are less concerned about weight, body shape, body composition (mass and fat proportions), and other specific worries typical in adolescents and young adults (Fernández-Bustos et al., 2015; Vega et al., 2015; Sabik and Versey, 2016; Irvine et al., 2019). As Clarke and Korotchenko (2011) pointed out, all aging signs are embodied, and it is not only in our mind that we experience age, but it is also through our bodies that we feel the psychosocial and physical consequences of growing older.

Across the lifespan, body image plays a vital role in self-concept and self-esteem. Body image problems have been associated in adolescence and youth with eating disorders, anxiety, and depression, but the psychological consequences of body dissatisfaction in older people are less known, and consequently there is a generational gap in research that needs to be filled (Deeks and McCabe, 2001; Tiggemann, 2004; Kilpela et al., 2015; Bouzas et al., 2019; Sánchez-Cabrero et al., 2019). The few studies that have addressed body image in both adulthood and old age have focused on female problems, particularly in menopausal-related issues (Deeks and McCabe, 2001; Webster and Tiggemann, 2003; Kilpela et al., 2015). For this reason, this study aims at filling this gap and providing data on body image dissatisfaction in maturity and old age.

Older people are inclined to accept their bodies better than teenagers do, and they are also less prone to developing eating and image disorders, yet this does not mean that they do not experience image problems at all (Webster and Tiggemann, 2003; McGuinness and Taylor, 2016). Indeed, the so-called "*maturity crisis*" is related, among other things, to how time takes its toll on physical appearance, making people feel sadder and disappointed in how they look (Gubrium and Holstein, 2006; Zdenko and Geiger-Zeman, 2015). Without a doubt, physical appearance decline is one of the most worrying signs that can make someone think of losing active lifestyles and see the possibility of developing physical and neurodegenerative diseases closer, and it can also awake thoughts of passing away. Not surprisingly, most people fear aging, and this becomes more patent at fifty, which makes this a significant age point. Despite being a psychosocial problem, particularly true of societies obsessed with youth, this has received little attention in the scientific literature (Tiggemann, 2004; Grogan, 2016; Cash, 2017). For instance, a systematic search in *PsycNet,* conducted in 2019 for this article, revealed that publications on body image focused on older people is less than the 5% of all articles published on this subject during the last 5 years.

Growing older does not only affect our perceptions of how we look, but it also affects the roles and social position that we identify ourselves with. In most modern societies, the status of older people is perceived to be lower and under-resourced. A significant number of retired people are very dependent on state support and retirement pensions to guarantee their primary living conditions. Therefore, the process of self-identification that takes place when someone feels that s/he is getting old implies a growing acceptance of new attributes and limitations. Sometimes these changes and adaptations come along with depressive symptoms or anxiety (Keyes and Westerhof, 2012). An intervention focused on body image could alleviate some of these problems by helping older people to keep positive attitudes and foster self-acceptance (Kozar, 2005; Mangweth-Matzek et al., 2006; McLean et al., 2011; Hudson et al., 2016; Mellor et al., 2017). In doing so, psychologists and mental health practitioners must become aware of the unique role that body satisfaction plays in accepting the self.

In the particular case of Spain, research on maturity and aging is even more necessary because demographically, it is one of the most aged countries worldwide (INE, Spanish Statistical and Office, 2019). And this trend will continue in the coming years, becoming a Spanish relevant social problem that needs psychosocial analysis and carefully planned interventions (Abellán et al., 2017).

Being satisfied with who we are is not only determined by our physical appearance but also by other variables. Particularly, by gender, age, place of residence (Swami et al., 2018), time of year and by whether we have a significant person or partner by our side (Markey et al., 2001; Davison and McCabe, 2005; Rodgers et al., 2015; Ridgway and Clayton, 2016). Regarding gender, older women tend to have less body satisfaction than men of the same age (Murray and Lewis, 2014; Tylka and Homan, 2015; Hudson et al., 2016; Cundall and Guo, 2017; Homan and Tylka, 2018). When compared with younger people, older people tend to experience less body dissatisfaction (Bucchianeri et al., 2014; Murray and Lewis, 2014), but this is not so clear as it has received little scholarly attention. As for having or not having a partner, being with someone is believed to have a positive impact on body satisfaction. However, Sánchez-Cabrero et al. (2019) found that the influence of marital status to body satisfaction could be mediated by gender in a more complex way, since married women were more dissatisfied with their body image in comparison with single women- In contrast, men were more satisfied regardless of their marital status (married or single). As can be seen, body satisfaction in older people could be the result of an intricate interaction between all these variables, and there is no evidence on how psychosocial interventions may also intervene in this process.

Currently, non-governmental organizations and public health services promote a variety of programs for older people trying to foster active aging. When it comes to body satisfaction, most of these interventions may be of little help since the scope of these programs is too broad, making it difficult to specifically address the acceptance of the body changes that come with age. The positive effects of participating in these non-specific programs may be due to the wellbeing experienced when relating to similar people, i.e., people of the same age, characteristics, and problems. In any case, it is difficult to know to what extent non-specific programs are truly effective and whether or not more specific programs on body satisfaction may be better instruments that we should rely on Castellano-Fuentes (2014), Roses-Gómez (2014), and Mellor et al. (2017).

As for intervention programs aimed at improving body image, the scientific literature shows that these produce outstanding results, from the classics of Cash (1997) and PICTA, Maganto et al. (2002), to current ones, such as those of, Kilpela et al. (2016), McCabe et al. (2017), and Bailey et al. (2019). However, none of them are intended for mature people, focusing instead on adolescent or young people, and mainly on the female population, except for the *IMAGINA* program by Sánchez-Cabrero (2012).

In this study, we examine body satisfaction in older people from an experimental perspective. Our aims are: (1) to describe body satisfaction of participants over 50 years old considering their age, gender, having a stable partner, time of the year, place of residence as intervening variables, and (2) To analyze body satisfaction improvement in older and mature people participating in a specific program on body satisfaction versus the improvement obtained in a non-specific program, and (3) to examine the relationship between age, gender, marital status, time of year, place of residence and body satisfaction regarding the experimental condition.

Regarding our first goal, the central hypothesis is that body satisfaction grows higher with age but not to the extent of making concern about physical appearance disappear (Webster and Tiggemann, 2003; McGuinness and Taylor, 2016; Sánchez-Cabrero et al., 2019). Regarding the second goal, the hypothesis is that, as suggested in previous literature on other age groups (Cash, 1997; Maganto et al., 2002; McCabe et al., 2017), the specific intervention on body image done in the experimental condition is going to have a positive influence on the evaluation of body satisfaction in the participants. This intervention consists of collective multi-thematic activities of a social and affective nature. Regarding the third goal that takes on the role of intervening variables in the experimental condition (gender, age, having a stable partner, time of the year, and place of residence), we hypothesize that gender is going to play a significant role in those participants above 50 years old (Tiggemann, 2004; Kilpela et al., 2015).

MATERIALS AND METHODS

Participants

In this study, 176 people over 50 years old participated with no payment offered, half of them in the experimental condition, and the other half in the control condition. The mean age and standard deviation were 64.03 ± 18.06. Gender and age distributions were as follows, 30 men (17%) and 146 women (83%), 83 under 65 years of age (active population in terms of work), and 93 over 65 years of age (retired according to the Spanish labor system). There were 117 participants in a stable relationship, 37 widows/widowers, 15 singles, and only seven of them were separated or divorced from a long-term partner. Regarding the place of residence and the time of year, 113 lived in urban places, and 63 in rural areas, 92 of were enrolled in the program during summer and 84 during winter.

All the attributive variables measured in the study were categorical, and age was recorded in six different groups to make it easier to compare and analyze it with the rest of the variables of the study. The distribution of participants into six groups allow us to study the trend in the age range studied, while taking the 65 years old as the tipping point that marks the retirement from the labor market.

The participants were all recruited *via* the Spanish *Red Cross* in the North-West of Spain, which is one of the most affected areas by aging population problems. All of them were Caucasian (this Spanish region is not racially diverse), half of them came from rural places (localities with less than 1000 inhabitants) and the other half from urban areas. Sampling was done by clusters, having a total of 10 groups of people over 50 years old that were willing to participate in social programs of the Spanish Red Cross. Half of these groups underwent the experimental treatment, and the other half served as control. The programs were implemented by the same monitors at two different times of the year: summer and winter. The assignment of participants to the groups was random, ensuring similar distributions of them to the control and experimental conditions, and the same with the time of program application and place of residence.

Data Obtaining Instruments

Body Shape Questionnaire (BSQ) developed by Cooper et al. (1987), which was adapted and scaled to Spanish participants by Raich et al. (1996). This is a self-report of 34 items following a Likert scale that goes from 1 (never) to 6 (always). The final score ranges from 34 to 204, and scoring above 110 indicates dissatisfaction and discomfort with physical appearance (Cooper et al., 1987). It is a reliable instrument since several studies have reported Cronbach's α between 0.95 and 0.97. In this study, Cronbach's alpha was 0.96, so it is near the values obtain by Cooper et al. (1987). Also, the *BSQ* has good external validity, i.e., it is convergent with other similar tools, such as the *Multidimensional Body Self-Relations Questionnaire, MBSRQ* (Cash, 2015) and the body dissatisfaction subscale of the *Eating Disorders Inventory*, *EDI* (Garner et al., 1983).

We used the *BSQ* because it continues to be one of the most widely used instruments in scientific research (Baile et al., 2002; Fernández-Bustos et al., 2015) and it remains a benchmark in body image studies. Proof of this is recent and cultural adaptations, for instance, to the Brazilian population (Conti et al., 2009), to the Colombian (Moreno et al., 2015), to the Norwegian (Kapstad et al., 2015) or the Korean (Kim and Chee, 2018), among others. Also, it has excellent psychometric properties and has been already adapted to Spanish. Besides, the lexical simplicity and brevity of its application make it the right choice for older people. Let us note that due to their age, the participants could get tired within a few minutes of evaluation, and that, in some cases, had low literacy skills.

Although older people tend to worry about aging signs, weight, and body changes, using the BSQ allows us to compare our results on aging people with other studies on younger participants, making it possible to examine body dissatisfaction across the lifespan. An ultimate reason for using BSQ is that currently, we do not have body image questionnaire specific for older people, and creating a new instrument would cause reliability problems, precluding us from comparing our results with existing literature.

Information about sociodemographic variables such as age, gender, and marital status was also collected *via* questionnaire. In contrast, the details about the time of year of program application, and place of residence was registered by the person who gathered and controlled the experimental data.

The BMI (Body Mass Index) was not evaluated since possible misinterpretations can occur due to the gradual shrinkage of the spine that occurs in older people that makes the BMI seem higher than it is. More importantly, in Spain (and particularly in rural areas), asking about this information can be seen as an intrusion on personal issues. We excluded from the study people with chronic severe health problems, obesity-related serious conditions, or extreme thinness to avoid any bias in the results.

As for the treatment of the experimental group, we used the *IMAGINA* Program that was specifically designed to improve the body image of mature and older adults in the Spanish population (Sánchez-Cabrero, 2012). It consists of eight sessions of 90–120 min to do in groups. The entertaining activities aim at improving the body image and self-esteem of participants, encouraging social participation, appearance acceptance, and healthy nutrition. It also enhances emotional intelligence, it promotes positive affective relations with people, and it helps re-evaluate self-expectations related to physical appearance and social interaction that can be harmful to the mental health of the participant. This program is unique in its field, and therefore the best option to study body image improvement of the participants in this study. In the satisfaction survey that participants completed in the pilot test, the program had an excellent acceptance (was rated 9 out of 10).

As a control treatment, we used the *"Spanish Red Cross Health Promotion Program for the older people"* that had an excellent acceptance among its participants. It has the same duration as *IMAGINA* (eight sessions of 90–120 min), and it was also designed for groups. Whereas this standard program fostered social interaction, it did not address the body image issues that *IMAGINA* did. Participants enjoyed group leisure activities and were trained in healthy habits.

Both treatments were carried out in the evening, twice a week, during a total of 4 weeks. The *BSQ* was not applied to those participants who did not attend every single session. Consequently, data from 10% of the participants were not included in the study. Since both programs were applied in groups, enjoying playful activities and positive social participation, the experimental attrition or mortality of both groups was reduced to a minimum.

Design and Procedure

We followed an experimental design to evaluate inter and intra-specific interactions between body image satisfaction (DV) and program participation: body image specific program vs. non-specific social program (intergroup or between subjects' IV effect), and before and after participating (intragroup or within subjects' IV effect). We controlled blocking variables through sample selection and randomization of the subjects into the experimental conditions. We also assessed the influence and interaction of age, gender, marital status, time of year, and place of residence as part of the study's goals.

There was a total of ten groups (five participating in the specific body image program and five in the non-specific program). Participants were allocated randomly to the control and experimental conditions. The experimental group participated in the "IMAGINA: Program to improve the self-esteem and body image in adults" (Sánchez-Cabrero, 2012), taking part in eight group sessions of 2 h each (two times per week, a total of 4 weeks). The control group participated in a non-specific psychosocial program implemented by the Spanish Red Cross, also with eight sessions of 2 h duration each.

The BSQ was applied at two different times, before and after the experimental treatment as follows: (1) pretest with the groups already formed and before participating in their assigned program; (2) posttest immediately after the end of the last session of the program. The application of BSQ was in paper format and done individually, although all participants of each group were in the same room at the same time. Each measurement had a proximate duration of 10 min to respond to 34 items.

According to the *Helsinki Declaration* (World Medical Association, 2013), we followed ethical principles for psychological research strictly. We informed all participants of the purpose of the study and that it had a non-profit nature and was non-sponsored, and gathered their consent to take part in the research afterward. The older people are vulnerable and, therefore, we made sure that they all understood our purposes and the possible benefits of participating in both programs correctly. It was possible to withdraw from the study, but none of the participants withdrew. The Institutional Review Board at Alfonso X el Sabio University approved the experimental protocol.

Data Analyses

To test our research hypotheses, we conducted descriptive and inferential analyses, more specifically, a paired samples *Student's t-test* to examine body image before and after participating in the two programs (intragroup IV effect), and a *One-way ANOVA* to assess the effect of each program (intergroup IV effect), sex, age, and marital status. This analysis was completed with *repeated measures ANOVA* using the *Pillai's Trace* and *Wilks' Lambda* statistics, as they offer opposite and complementary results of the inter-intragroup effect of independent variables. We considered that assessing variances and covariances sphericity in the multivariate analyses was not necessary because there only were two intra levels, and thus, the covariance is equal to itself.

RESULTS

Table 1 shows descriptive analyses of the *BSQ* test in both conditions (experimental and control) before and after participants took place in them, and the difference between these two moments (*paired samples test)*.

The results of the paired samples test (intragroup effect) indicate that the improvement is higher in the *IMAGINA* body image program than in the non-specific intervention (M = 6.75 *versus* M = 0.75), and this result is statistically significant in the experimental condition (t = 6.782, p = 0.000). Besides, the improvement is not significant in the control condition alone (t = 0.883, p = 0.380), which is an indication of a noteworthy improvement related to the *IMAGINA* body image program versus the non-specific intervention (*Cohen's d = 0.721 versus* 0.94). However, it is necessary to use multivariate analyses, such as the *Repeated Measures ANOVA*, to confirm whether the effect of *IMAGINA* was higher than the non-specific program or if, on the contrary, these differences were due to chance. In this sense, **Table 2** shows a *One-Way ANOVA* (intergroup effect), which compares *BSQ* at both moment (pre and post-treatment) and both conditions (control vs. experimental) as well as the difference between these two moments (pre-post difference). Both pre (F = 0.56, p = 0.455) and post-condition (F = 1.108, p = 0.294) show non-significant mean differences between the experimental and control conditions. However, there is a significant improvement in *BSQ* in the pre-post difference (F = 21.019, p = 000).

Finally, in **Table 3**, we can see the results of the *repeated measurements ANOVA* (inter-intra group effect), that also points to the effectiveness of the *IMAGINA* body satisfaction program over the non-specific one since all the multivariate contrasts are statistically significant (p = 0.000).

Gender, Age, Marital Status, Time of Year and Place of Residence Differences

Table 4 shows the mean and standard deviations of *BSQ* in both conditions and moments (pre and post) by gender, age marital status, time of year, and place of residence, as well as the difference between these two moments (*paired samples test).*

Regarding gender, male participants were more satisfied with their bodies than females, and this difference is even more evident after taking part in the *IMAGINA* program (post-test). Moreover, the pre-post difference is statistically significant for both men and women only in the experimental condition (Women: t = 5.756, p = 0.000; Men: t = 4.646, p = 0.000).

TABLE 2 | BSQ differences in both moments (One-way ANOVA between experimental conditions).

Pre-test			Post-test			Pre-post		
F	*p*	Eta squared	*F*	*p*	Eta squared	*F*	*p*	Eta squared
0.56	0.455	0.003	1.108	0.294	0.006	21.019	0.000	0.107

As for the participant's age, since they have been classified into 6 groups, we applied Bonferroni's corrections to avoid the risk of error type I when making multiple comparisons. This way, the result is only considered significant when p is less than 0.08. Body satisfaction improved in all groups for the experimental condition, but this result was only significant for participants 50 to 54 years old (t = 4,70; p = 0.000) and 65 to 69 (t = 1.038; p = 0.001). Again, there were no differences in any of the groups of the control condition.

Regarding marital status (recorded into four groups), we applied Bonferroni's corrections to avoid the risk of error type I when making multiple comparisons, considering a result significant when p is below 0.125. These results are affected by the small sample size of some of the groups, such as separated or divorced (n = 7) and singles (n = 15). Separated and divorced individuals are less satisfied with their image before participating, and this was true in both conditions (M = 104.07; SD = 25.4 in the experimental group; M = 89.7; SD = 15.9 in the control group), which seems to indicate that their marital status is negatively related to their body satisfaction. Despite this unfavorable initial result, it is the group that improves more when participating in the *IMAGINA* program (M = 12.7; *Cohen's d* = 2.787), yet these results are not significant (p = 0.04). As for the singles, they are the ones with the highest initial body satisfaction levels (M = 63.2; SD = 15.8 in experimental group; M = 49; SD = 10 in the control group). However, taking part in the control program seems to be a negative experience for them since their body satisfaction scores measured in the pre-post difference are negative (−3.8), although this is not a significant result (p = 0.188). The only groups whose sample size was acceptable was that of participants with stable relationships, i.e., in a couple (n = 117) and widows/widowers (n = 37). In these cases, the *IMAGINA* body program had a positive impact as they improved their satisfaction significantly (p = 0.000 and p = 0.007, respectively).

The time of year at which the program took place did not affect the control group significantly, but it did the experimental group. In the experimental group, there were higher scores in winter than in summer (M = 9.44 and M = 4.40, respectively), although

TABLE 1 | Means and standard deviations of the BSQ test in both conditions and moments (pre, post) and pre-post-test difference (paired samples test).

Experimental group (n = 88)								Control group (n = 88)							
Pre-test		Post-test		Pre-post				Pre-test		Post-test		Pre-post			
M	*SD*	*M*	*SD*	*M*	*SD*	*p*	*Cohen's d*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*p*	*Cohen's d*
71.9	24.2	65.1	21.4	6.75	9.34	0.000	0.721	69.2	22.7	68.5	20.9	0.75	7.97	0.380	0.094

TABLE 3 | Multivariate test.

Effect	Statistical tools	Value	*F*	Gl. hyp.	Gl error	*p*	Partial Eta Squared
BSQ differences between the PRE and POST test	Pillai's Trace	0.16	32.84	1	174	0.000	0.159
	Wilks' Lambda	0.84	32.84	1	174	0.000	0.159
Impact of the variable "Condition" (inter) over the PRE and POST treatment measurement of the BSQ test (intra)	Pillai's Trace	0.11	21.02	1	174	0.000	0.108
	Wilks' Lambda	0.89	21.02	1	174	0.000	0.108
Intercept	*MS* = 1659627.56		1729.82	1	174	0.000	0.909

MS, mean square.

TABLE 4 | Age, gender, marital status, time of year, and place of residence differences (paired samples test).

	Experimental group (n = 88)				Control group (n = 88)			
	Pre-test	Post-test	Pre-post		Pre-test	Post-test	Pre-post	
	M (SD)	*M (SD)*	*M (SD)*	*p (Cohen's d)*	*M (SD)*	*M (SD)*	*M (SD)*	*p (Cohen's d)*
Gender								
WOMAN (n = 146)	71.9 (25.2)	65.3 (22.0)	6.6 (9.85)	(0.000) 0.673	72.3 (21.4)	71.3 (19.8)	1.07 (8.29)	(0.277) 0.129
MAN (n = 30)	71.5 (18.8)	63.9 (18.2)	7.57 (6.1)	(0.000) 1.239	55.2 (24.0)	55.9 (21.6)	−0.69 (6.37)	(0.672) 0.109
Age								
From 50 to 54 (n = 30)	78.3 (28.6)	66.6 (23.3)	11.74 (10.89)	(0.000) 1.076	80.1 (25.9)	78.0 (23.0)	2.09 (6.11)	(0.283) 0.346
From 55 to 59 (n = 22)	87.9 (25.1)	80.1 (2.9)	7.71 (10.13)	(0.090) 0.763	72.9 (20.9)	73.3 (23.2)	−0.33 (6.33)	(0.841) 0.054
From 60 to 64 (n = 31)	72.8 (23.1)	68.5 (19.5)	4.31 (7.52)	(0.037) 0.575	75.0 (25.5)	76.3 (20.7)	−1.33 (8.72)	(0.563) 0.152
From 65 to 69 (n = 47)	72.1 (24.8)	65.5 (24.5)	6.55 (7.92)	(0.001) 0.822	72.0 (20.5)	69.2 (17.9)	2.72 (9.51)	(0.166) 0.286
From 70 to 74 (n = 27)	64.9 (15.8)	59.3 (15.1)	5.64 (10.29)	(0.061) 1.034	57.6 (18.6)	58.4 (15.4)	−0.77 (8.16)	(0.740) 0.089
Over 75 (n = 19)	56.1 (16.6)	53.6 (16.7)	2.5 (7.62)	(0.327) 0.328	49.2 (12.4)	48.1 (12.1)	1.11 (6.41)	(0.617) 0.173
Marital status								
In couple (n = 117)	73.8 (23.4)	67.3 (19.9)	6.53 (10.12)	(0.000) 0.647	71.3 (23.7)	69.9 (21.8)	1.35 (8.23)	(0.209) 0.164
Separated (n = 7)	104.7 (25.4)	92.0 (25.4)	12.67 (4.51)	(0.040) 2.787	89.7 (15.9)	88.2 (15.6)	1.5 (4.43)	(0.547) 0.339
Single (n = 15)	63.2 (15.8)	56.2 (16.7)	7 (6.51)	(0.008) 1.075	49.0 (10.0)	52.8 (12.3)	−3.8 (5.36)	(0.188) 0.708
Widow/widower (n = 37)	65.1 (26.2)	58.8 (24.1)	6.75 (9.34)	(0.007) 0.719	63.6 (18.3)	63.7 (16.8)	−0.11 (8.24)	(0.956) 0.012
Time of year								
Summer (n = 92)	72.1 (21.2)	67.7 (20.0)	4.40 (9.46)	(0.003) 0.465	70.2 (22.5)	69.4 (20.1)	0.78 (8.93)	(0.562) 0.088
Winter (n = 84)	71.6 (27.5)	62.2 (22.8)	9.44 (8.54)	(0.000) 1.104	68.2 (23.1)	67.5 (21.8)	0.72 (6.93)	(0.499) 0.104
Place of residence								
Rural (n = 63)	70.2 (18.4)	66.0 (19.1)	4.21 (8.69)	(0.008) 0.484	65.6 (20.6)	64.6 (17.8)	0.93 (9.28)	(0.593) 0.100
Urban (n = 113)	72.9 (27.3)	64.6 (22.9)	8.35 (9.45)	(0.000) 0.887	71.0 (23.6)	70.3 (22.1)	0.66 (7.33)	(0.491) 0.090

the improvement was significant in both seasons $p = 0.003$ and $p = 0.000$, respectively.

Finally, regarding the place of residence, there were differences between both groups since the improvement was higher in urban participants ($M = 8.35$) than in rural participants ($M = 4.21$) in the experimental condition. The size of the effect is only significant in the experimental condition, as it happens with the rest of the attributive variables. Again, there were no significant differences in any of the groups of the control condition.

As can be seen, age, gender, time of year, and place of residence have less effect on body satisfaction in control groups than in the *IMAGINA* program groups, as shown by the *Cohen's d*. More specifically, if we look at the effect of the intergroup (IV) in **Table 5**, we can see how the results obtained in the *One-Way ANOVA* confirm that most of the significant differences are in the pre-post differences. Besides, the effect size of pre-post difference (*Eta Squared*) is bigger than the pre and post measures alone.

Finally, **Table 6** shows the multivariate analyses with repeated measures (inter-intragroup effect) that indicate that age, gender, marital status, time of year, and place of residence do not interfere with the effectiveness of the treatment (*IMAGINA* program) as the effect is non-significant.

DISCUSSION

Our results show that those participants who partook in the *IMAGINA* body image program improved their satisfaction toward their body look, whereas those who participated in a non-specific program did not experience any significant improvement. The score differences between the two conditions (6.75 points of improvement in the experimental group vs. 0.75 points in the control condition, $p = 0.000$) are in line with what positive body image theory claims, i.e., that self-image

TABLE 5 | BSQ inter analysis by age, gender, marital status, time of year and place of residence across conditions (One-way ANOVA).

	Pre-test			Post-test			Pre-post		
	F	*p*	Eta squared	*F*	*p*	Eta squared	*F*	*p*	Eta squared
Gender									
WOMAN	0.011	0.918	0.000	2.918	0.09	0.019	13.4	0.000	0.085
MAN	4.203	0.050	0.131	1.2	0.283	0.041	13.07	0.001	0.318
Age									
From 50 to 54	0.029	0.667	0.001	1.683	0.205	0.056	7.24	0.012	0.205
From 55 to 59	2.154	0.158	0.097	0.444	0.513	0.021	5.253	0.033	0.208
From 60 to 64	0.063	0.804	0.002	1.176	0.287	0.038	3.741	0.063	0.114
From 65 to 69	0.000	0.984	0.000	0.355	0.554	0.007	2.209	0.144	0.046
From 70 to 74	1.223	0.279	0.046	0.024	0.879	0.000	3.188	0.086	0.113
Over 75	1.025	0.326	0.056	0.659	0.428	0.037	0.182	0.675	0.010
Marital status									
In couple	0.326	0.569	0.002	0.482	0.489	0.004	9.263	0.003	0.074
Separated	0.928	0.38	0.156	0.06	0.816	0.012	5.253	0.022	0.682
Single	3.285	0.093	0.202	0.162	0.694	0.012	10.17	0.007	0.439
Widow/widower	0.04	0.843	0.001	0.532	0.47	0.015	5.281	0.028	0.131
Time of year									
Summer	0.167	0.684	0.001	0.178	0.674	0.002	3.568	0.062	0.038
Winter	0.388	0.535	0.004	1.173	0.282	0.014	26.529	0.000	0.244
Place of residence									
Rural	0.882	0.351	0.014	0.083	0.775	0.001	2.088	0.154	0.033
Urban	0.158	0.692	0.001	1.867	0.175	0.017	23.583	0.000	0.175

satisfaction can be fostered (Tylka and Homan, 2015; Homan and Tylka, 2018). This experimental study is also coherent with other studies suggesting that tailored programs with specific scopes are better instruments than preventive interventions that are non-specifically orientated (Roses-Gómez, 2014; Kilpela et al., 2015; Hudson et al., 2016; McCabe et al., 2017; Mellor et al., 2017; Bailey et al., 2019). Besides, our results also show the goodness of design of the *IMAGINA* program by Sánchez-Cabrero (2012) when used with participants over 50 years old.

The above results have clear clinical and scientific implications, as they show that we can intervene on body image at all ages and that physical appearance continues to be a relevant concern in the last phases of life. Moreover, the inclusion of body image intervention on mature and aging people can be a complementary action to the medical attention given to patients who are suffering depressive or altered moods. In this sense, it would be desirable to explore further the benefits of body satisfaction intervention on mature or older people and its possible benefits on mental health in both a preventive and palliative way. Also, we should look scientifically at the process of body image satisfaction in old age, determining its conditioning, limiting, and positive effects on mood and social interaction.

In our society, image and physical appearance are matters of great social importance due to the role that media usage (e.g., Internet, TV, magazines) plays in appearance comparisons, meaning that we are constantly exposed to "ideals" of beauty, health and fitness to live up to Fardouly et al. (2015) and Ridgway and Clayton (2016). This also happens in those groups who are not directly targeted by these media portrayals, such as older people (Raich, 2004; Thompson, 2004; Cash, 2017; Mellor et al., 2017). Despite its social and health relevance, body satisfaction has not received much scholarly attention, particularly in Spain, where there are no similar studies. For this reason, it is hard to establish any comparison. However, our participants' scores on body satisfaction assessed with the *BSQ* are similar to those reported in previous studies validating this tool. More specifically, we found a score of 71.9 and 72.3 (experimental and control group, respectively) for women, which is lower but in line with the 84.7 of Cooper et al. (1987) and the 84.75 of Raich et al. (1996). In the 21st century, the study of Baile et al. (2002) with more than five hundred preadolescents found a score of 81.2 among girls between 15 and 16 years old, and 79.49 for girls between 17 and 19. Another recent study by Conti et al. (2009), showed an average of 73.9 among Brazilian adolescents, 88.3 for women and 57.1 for men, reflecting a very pronounced gender difference. Finally, the latest study of Fernández-Bustos et al. (2015) conducted with more than five hundred female teenagers and pre-teenagers also reported similar values, yet no specific mean and standard deviation values were provided. If we compare these results with the ones obtained in this study with people over 50 years old ($M = 70.54$; $SD = 23.44$). We can see that even though there are differences between age-groups, the range that includes the 68% of the data (i.e., the area around one SD over the mean) overlaps in more than 60% of the cases. Thus, we could conclude that most of the people over 50 years old may have similar body dissatisfaction levels as teenagers and young adults.

Our results also support the conclusion of other studies showing how concerns about physical appearance do not disappear as people age (McGuinness and Taylor, 2016; Bouzas et al., 2019; Cameron et al., 2019). More specifically, we refer to

TABLE 6 | Multivariate contrasts of gender, age, gender, marital status, time of year, and place of residence (inter and intra analyses).

Effect	Statistical tool	Value	*F*	Gl. hip.	Gl. error	*p*	Partial Eta Squared
Impact of the variable Gender (inter) over the PRE and POST treatment measurement of the BSQ (intra) test	Pillai's Trace	0.00	0.05	1	172	0.824	0.000
	Wilks' Lambda	1.00	0.05	1	172	0.824	0.000
Impact of the variable Gender (inter) over the PRE and POST treatment measurement of the BSQ (intra) test keeping in mind the variable Condition (inter)	Pillai's Trace	0.00	0.61	1	172	0.436	0.004
	Wilks' Lambda	1.00	0.61	1	172	0.436	0.004
Intercept BSQ-Gender	*MS* = 861914.63		926.61	1	172	0.000	0.843
Impact of the variable Age (inter) over the PRE and POST treatment measurement of the BSQ (intra) test	Pillai's Trace	0.05	1.60	5	164	0.163	0.047
	Wilks' Lambda	0.95	1.60	5	164	0.163	0.047
Impact of the variable Age (inter) over the PRE and POST treatment measurement of the BSQ (intra) test keeping in mind the variable Condition (inter)	Pillai's Trace	0.02	0.72	5	164	0.606	0.022
	Wilks' Lambda	0.98	0.72	5	164	0.606	0.022
Intercept BSQ-Age	*MS* = 1443252.91		1652.99	1	172	0.000	0.910
Impact of the variable Marital status (inter) over the PRE and POST treatment measurement of the BSQ (intra) test	Pillai's Trace	0.01	0.68	3	168	0.564	0.012
	Wilks' Lambda	0.99	0.68	3	168	0.564	0.012
Impact of the variable Marital status (inter) over the PRE and POST treatment measurement of the BSQ (intra) test keeping in mind the variable Condition (inter)	Pillai's Trace	0.01	0.62	3	168	0.599	0.011
	Wilks' Lambda	0.99	0.62	3	168	0.599	0.011
Intercept BSQ-Marital Status	*MS* = 621802.63		695.612	1	172	0.000	0.805
Impact of the variable Time of year (inter) over the PRE and POST treatment measurement of the BSQ (intra) test	Pillai's Trace	0.02	3.72	1	172	0.055	0.021
	Wilks' Lambda	0.98	2.04	1	172	0.055	0.021
Impact of the variable Time of year (inter) over the PRE and POST treatment measurement of the BSQ (intra) test keeping in mind the variable Condition (inter)	Pillai's Trace	0.02	3.90	1	172	0.051	0.022
	Wilks' Lambda	0.98	3.90	1	172	0.051	0.022
Intercept BSQ-Time of Year	*MS* = 1652369.59		1708.12	1	172	0.000	0.909
Impact of the variable Place of residence (inter) over the PRE and POST treatment measurement of the BSQ (intra) test	Pillai's Trace	0.01	2.04	1	172	0.155	0.012
	Wilks' Lambda	0.99	2.04	1	172	0.155	0.012
Impact of the variable Place of residence (inter) over the PRE and POST treatment measurement of the BSQ (intra) test keeping in mind the variable Condition (inter)	Pillai's Trace	0.02	2.65	1	172	0.106	0.015
	Wilks' Lambda	0.98	2.65	1	172	0.106	0.015
Intercept BSQ-place of residence	*MS* = 1496025,23		1552,66	1	172	0.000	0.900

MS, mean square.

the study of Mangweth-Matzek et al. (2006) and the longitudinal study of McLean et al. (2011). As Gubrium and Holstein (2006) hypothesized, older people may perceive their appearance as a "*Mask*" of their "*True*" physical self that was captured by the pictures taken in their youth. Such disconnection or non-identification with the current physical self could alter their perception, making them more dissatisfied with their body image. Consequently, body image does play a significant role in emotional health (i.e., self-esteem and self-concept) and life satisfaction (Castellano-Fuentes, 2014; Vega et al., 2015; Zdenko and Geiger-Zeman, 2015). Therefore, more specific body image programs like *IMAGINA* (Sánchez-Cabrero, 2012), presented here, should be developed and promoted by governments and non-governmental organizations (Tiggemann, 2004; Kilpela et al., 2015; Bouzas et al., 2019).

Even though age is positively related to body satisfaction, it has been suggested that it only matters if other social and biological factors are present, such as losing social expectations or perceiving that physical decline is occurring (Deeks and McCabe, 2001; Kozar, 2005; Hofmeier et al., 2017). Our data showed that although body satisfaction tends to improve with age, it goes down between 55 and 59 years, a period in which there is a peak in body dissatisfaction that cannot be explained by other attributive variables. However, these differences are not significant for any age group and they may be due to chance. On the other hand, the improvement in body satisfaction that happens in the experimental group is significantly higher in the period of 65 to 69 years. This effect is probably due to the retirement process, which quantitatively and qualitatively transforms the social interactions of older people, making the positive effect of participating in the body image program more salient. In light of these results, we need new and more specific studies about the role of age in body satisfaction of older people.

Interestingly, in our study, we found that growing older do not eliminate the concern for physical appearance, which happens to be strongly related to gender. A fact that is line with what other scholars have suggested when highlighting that the body is sexed and that it is such sexualized embodiment that determines which features and attributes are perceived as belonging to the self-image (Longo, 2015; Cash, 2017; Cundall and Guo, 2017).

For instance, according to traditional standards, female and male traits arise from an active-passive polarity (strength, endurance, energy, audacity for males, and their opposites for females) that influences how we judge our body (Raich, 2004; Sánchez-Cabrero and Maganto, 2009; Sánchez et al., 2015). Also, our results showed that men were more satisfied with their body image, and this was true for both conditions. Gender differences could be explained in terms of social exposure and judgments, which make men realize that as they age, they lose the "*active*" traits mentioned above, becoming less masculine (Rodgers et al., 2015; Cash, 2017). This is compatible with the fact that women are more dissatisfied with their body image and critical with themselves across the lifespan (Mellor et al., 2010; Grogan, 2016). Also, according to Davison and McCabe (2005), body satisfaction in men is more linked to affective and sexual factors (inter competition), whereas in women, it is more related to social qualities and interaction with other women (intra competition). However, these gender results should be addressed with caution, since the difference in the number of female (n = 146) and male participants (n = 30) is considerable and may have biased the results. This undesired situation was due to the higher interest of women in participating in social group programs, a gender difference that reflects social reality. Besides, the risk of experimental attrition for 8 weeks is high, and therefore, we could not afford to wait for having more men to enroll with us.

In general, our results show that singlehood is positively related to body image (M = 58.47 in *BSQ*; Women = 63.2 and Men = 52.8) and that people more dissatisfied were separated or divorced (M = 96.14 in *BSQ*; Women = 104.7; Men = 89.7) as well as people with partners (M = 72.51 in *BSQ*; Women = 73.8; Men = 71.3). It is worth noting that the *IMAGINA* program benefited the participants who, according to their satisfaction level, needed the most help (separated and divorced people).

Finally, the last two variables evaluated, time of the year and place of residence, behave similarly. There are no clear differences in body satisfaction, but there are in how *IMAGINA* program affects: being urban or participating in *IMAGINA* during winter doubles its positive effects. About the season, the body silhouette is more hidden under the voluminous warming clothing that people use in winter, making them feel better or less concerned about how they look. As for the place of residence, in urban areas there may be fewer social interaction opportunities for older people, and hence, the effects of the social activities of the program may be more salient.

This study is not exempt from limitations, the main one being that there are no similar studies to compare it with and, therefore, more replications are needed to validate our results. Also, we only measured body satisfaction and did not include other related variables, but this was because the program whose efficacy we wanted to analyze had a strong focus on this variable.

Another relevant limitation is the lack of body image programs conducted in maturity and old age, which has limited the treatment only to a single alternative. However, *IMAGINA* has proved to be very useful in its work, as shown by the results obtained.

Finally, two notable shortcomings regarding the selection of variables are worth mentioning. Firstly, due to the place in which the study took place, all participants were white, and ethnicity could not be analyzed. Secondly, we decided not to use the BMI because when aging, the spine curve reduces the height of the older person, and therefore, the BMI may not be a reliable indicator. Also, asking for this information is culturally problematic and can be seen as invasive, generating discomfort in the participants.

To conclude, mature and older people are concerned with their image and suffer from not fitting in with the beauty and health standards that our current society impose on all of us. This is true for men and women, yet it is experienced differently and depends as well on social variables like marital status. Let us not forget that older people struggle to accept their individuality in a society that celebrates youth and dislike aging, being different, or not fitting the beauty standards. This concerns the media and advertising sector in which more psychosocial research and actions are needed since too often they are reaching at-risk groups (i.e., children and older people) that were not meant to be influenced by their advertising and marketing content.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The study was conducted according to the Declaration of Helsinki and approved by the Institutional Review Board at Alfonso X el Sabio University. Written informed consent was obtained from all participants of this study.

AUTHOR CONTRIBUTIONS

RS-C led the research, analyzed the data, and wrote the main body of the manuscript. AL-M reviewed the data, translation, and experimental design presented in the reports of this manuscript. AA-G and CM-M reviewed and corrected the statistical analyses of the results, and reviewed the bibliography. All authors reviewed the final manuscript.

REFERENCES

Abellán, A., Ayala, A., and Pujol, R. (2017). Un perfil de las personas mayores en España, 2017. Indicadores estadísticos básicos. *Informes Envejecimiento En Red* 15, 1–48. doi: 10.2471/BLT.16.187617

Baile, J. I., Guillén, F., and Garrido, E. (2002). Insatisfacción corporal en adolescentes medida con el Body Shape Questionnaire (BSQ): Efecto del anonimato, el sexo y la edad. *Revista Internacional de Psicología Clínica y de La Salud* 2, 439–450. doi: 10.20453/rnp.v75i3.1226

Bailey, K. A., Gammage, K. L., and van Ingen, C. (2019). Designing and implementing a positive body image program: unchartered territory with a diverse team of participants. *Action Res.* 17, 146–161. doi: 10.1177/1476750318821169

Bouzas, C., Bibiloni, M. D. M., and Tur, J. A. (2019). Relationship between body image and body weight control in overweight= 55-year-old adults: a systematic review. *Int. J. Environ Res. Public Health* 16:1622. doi: 10.3390/ijerph16091622

Bucchianeri, M. M., Serrano, J. L., Pastula, A., and Corning, A. F. (2014). Drive for muscularity is heightened in body-dissatisfied men who socially compare. *Eat. Disord.* 22, 221–232. doi: 10.1080/10640266.2013.874825

Cameron, E., Ward, P., Mandville-Anstey, S. A., and Coombs, A. (2019). The female aging body: a systematic review of female perspectives on aging, health, and body image. *J. Women Aging* 31, 3–17. doi: 10.1080/08952841.2018.1449586

Cash, T. F. (1997). *The Body Image Workbook: An 8-Step Program for Learning to Like Your Looks*. Oakland, CA: New Harbinger Publications, Inc.

Cash, T. F. (2015). "Multidimensional Body–Self Relations Questionnaire (MBSRQ)," in *Encyclopedia of Feeding and Eating Disorders*. Ed. T. Wade, Singapore: Springer, 1–4. doi: 10.1007/978-981-287-087-2_3-1

Cash, T. F. (2017). Body image: a joyous journey. *Body Image* 23, A1–A2. doi: 10.1016/j.bodyim.2017.11.001

Castellano-Fuentes, C. L. (2014). La influencia del apoyo social en el estado emocional y las actitudes hacia la vejez y el envejecimiento en una muestra de ancianos. *Int. J. Psychol. Psychol. Ther.* 14, 365–377. doi: 10.1016/j.regg.2013.06.001

Clarke, L. H., and Korotchenko, A. (2011). Aging and the body: a review. *Can. J. Aging* 30, 495–510. doi: 10.1017/S0714980811000274

Conti, M. A., Cordás, T. A., and Latorre, M. R. D. O. (2009). A study of the validity and reliability of the Brazilian version of the Body Shape Questionnaire (BSQ) among adolescents. *Revista Brasileira de Saúde Materno Infantil* 9, 331–338. doi: 10.1590/S1519-38292009000300012

Cooper, P. J., Taylor, M. J., Cooper, Z., and Fairburn, C. G. (1987). The development and validation of the Body Shape Questionnaire. *Int. J. Eat. Disord.* 6, 485–494 doi: 10.1002/1098-108x(198707)6:4<485::aid-eat2260060405>3.0.co;2-o

Cundall, A., and Guo, K. (2017). Women gaze behaviour in assessing female bodies: the effects of clothing, body size, own body composition and body satisfaction. *Psychol. Res.* 81, 1–12. doi: 10.1007/s00426-015-0726-1

Davison, T. E., and McCabe, M. P. (2005). Relationships between men's and women's body image and their psychological, social, and sexual functioning. *Sex Roles* 52, 463–475. doi: 10.1007/s11199-005-3712-z

Deeks, A. A., and McCabe, M. P. (2001). Menopausal stage and age and perceptions of body image. *Psychol. Health* 16, 367–379. doi: 10.1080/08870440108405513

Fardouly, J., Diedrichs, P. C., Vartanian, L. R., and Halliwell, E. (2015). The mediating role of appearance comparisons in the relationship between media usage and self-objectification in young women. *Psychol. Women Q.* 39, 447–457. doi: 10.1177/0361684315581841

Fernández-Bustos, J.-G., González-Martí, I., Contreras, O., and Cuevas, R. (2015). Relación entre imagen corporal y autoconcepto físico en mujeres adolescentes. *Revista Latinoamericana de Psicología* 47, 25–33. doi: 10.1016/S0120-0534(15)30003-0

Garner, D. M., Olmstead, M. P., and Polivy, J. (1983). Development and validation of a multidimensional eating disorder inventory for anorexia nervosa and bulimia. *Int. J. Eat. Disord.* 2, 15–34. doi: 10.1002/1098-108x(198321)2:2<15::aid-eat2260020203>3.0.co;2-6

Grogan, S. (2016). *Body Image: Understanding Body Dissatisfaction in Men, Women and Children*. London: Routledge, doi: 10.4324/9781315681528

Gubrium, J. F., and Holstein, J. A. (2006). The Life Course. in *Handbook of Symbolic Interactionism*. eds N. J. Herman, and L. Reynolds, Walnut Creek, CA: AltaMira Press, 835–855.

Hofmeier, S. M., Runfola, C. D., Sala, M., Gagne, D. A., Brownley, K. A., and Bulik, C. M. (2017). Body image, aging, identity in women over 50: the Gender and Body Image (GABI) study. *J. Women & Aging* 29, 3–14. doi: 10.1080/08952841.2015.1065140

Homan, K. J., and Tylka, T. L. (2018). Development and exploration of the gratitude model of body appreciation in women. *Body Image* 25, 14–22. doi: 10.1016/j.bodyim.2018.01.008

Hudson, N. W., Lucas, R. E., and Donnellan, M. B. (2016). Getting older, feeling less? A cross-sectional and longitudinal investigation of developmental patterns in experiential well-being. *Psychol. Aging* 31, 847–861. doi: 10.1037/pag0000138

INE, Spanish Statistical, and Office (2019). *Statistical Information on Demography and Population*. Available at: http://www.ine.es/dyngs/INEbase/es/categoria.htm?c=Estadistica_P&cid=1254735572981 (accessed September 12, 2019).

Irvine, K. R., McCarty, K., McKenzie, K. J., Pollet, T. V., Cornelissen, K. K., Tovée, M. J., et al. (2019). Distorted body image influences body schema in individuals with negative bodily attitudes. *Neuropsychologia* 122, 38–50. doi: 10.1016/j.neuropsychologia.2018.11.015

Kapstad, H., Nelson, M., Øverås, M., and Rø, Ø (2015). Validation of the Norwegian short version of the Body Shape Questionnaire (BSQ-14). *Nordic J Psychiatry* 69, 509–514. doi: 10.3109/08039488.2015.1009486

Keyes, C. L., and Westerhof, G. J. (2012). Chronological and subjective age differences in flourishing mental health and major depressive episode. *Aging Mental Health* 16, 67–74. doi: 10.1080/13607863.2011.596811

Kilpela, L. S., Becker, C. B., Wesley, N., and Stewart, T. (2015). Body image in adult women: Moving beyond the younger years. *Adv. Eat. Disord.* 3, 144–164. doi: 10.1080/21662630.2015.1012728

Kilpela, L. S., Blomquist, K., Verzijl, C., Wilfred, S., Beyl, R., and Becker, C. B. (2016). The body project 4 all: A pilot randomized controlled trial of a mixed-gender dissonance-based body image program. *Int. J. Eat. Disord.* 49, 591–602. doi: 10.1002/eat.22562

Kim, T. S., and Chee, I. S. (2018). The reliability and validity of the Korean version of the Body Shape Questionnaire. *Anxiety Mood* 14:36. doi: 10.22722/KJPM.2018.26.2.152

Kozar, J. M. (2005). Relationship of attitudes toward advertising images and self-perceptions of older women. *Dissert. Abstr. Int. Sec. A* 65:3116. doi: 10.31274/rtd-180813-14309

Longo, M. R. (2015). Implicit and explicit body representations. *Eur. Psychol.* 10, 6–15. doi: 10.1027/1016-9040/a000198

Maganto, C., Del Río, A., and Roiz Mur, O. (2002). *Programa Preventivo Sobre Imagen Corporal y Trastornos de la Alimentación (PICTA)*. Madrid: TEA Ediciones.

Maganto, C., Garaigordobil, M., and Kortabarria, L. (2016). Eating problems in adolescents and youths: explanatory variables. *Span. J. Psychol.* 19:E81. doi: 10.1017/sjp.2016.74

Mangweth-Matzek, B., Rupp, C. I, Hausmann, A., Assmayr, K., Mariacher, E., Kemmler, G., et al. (2006). Never too old for eating disorders or body dissatisfaction: a community study of elderly women. *Int. J. Eat. Disord.* 39, 583–586. doi: 10.1002/eat.20327

Markey, C. N., Markey, P. M., and Birch, L. L. (2001). Interpersonal predictors of dieting practices among married couples. *J. Fam. Psychol.* 15, 464–475. doi: 10.1037//0893-3200.15.3.464

McCabe, M. P., Connaughton, C., Tatangelo, G., Mellor, D., and Busija, L. (2017). Healthy me: A gender-specific program to address body image concerns and risk factors among preadolescents. *Body Image* 20, 20–30. doi: 10.1016/j.bodyim.2016.10.007

McGuinness, S., and Taylor, J. E. (2016). Understanding body image dissatisfaction and disordered eating in midlife adults. *New Zealand J. Psychol.* 45, 4–12.

McLean, S. A., Paxton, S. J., and Wertheim, E. H. (2011). A body image and disordered eating intervention for women in midlife: a randomized controlled trial. *J. Consult. Clin. Psychol.* 79, 751–758. doi: 10.1037/a0026094

Mellor, D., Connaughton, C., McCabe, M. P., and Tatangelo, G. (2017). Better with age: a health promotion program for men at midlife. *Psychol. Men Mascul.* 18, 40–49. doi: 10.1037/men0000037

Mellor, D., Fuller-Tyszkiewicz, M., McCabe, P. M., and Ricciardelli, L. (2010). Body image and self-esteem across age and gender: a short-term longitudinal study. *Sex Roles* 63, 672–681. doi: 10.1007/s11199-010-9813-3

Moreno, D. C., Montaño, I. L., Prieto, G. A., and Pérez-Acosta, A. M. (2015). Validación del Body Shape Questionnaire (Cuestionario de la Figura Corporal) BSQ para la población colombiana. *Acta Colombiana Psicología* 10, 15–23.

Murray, T., and Lewis, V. (2014). Gender-role conflict and men's body satisfaction: The moderating role of age. *Psychol. Men Mascul.* 15, 40–48. doi: 10.1037/a0030959

Raich, R. M. (2004). Una perspectiva desde la psicología de la salud de la imagen corporal. *Avances En Psicología Latinoamericana* 22, 15–27. doi: 10.21134/pssa.v6i1.1317

Raich, R. M., Mora, M., Soler, A., Ávila, C., Clos, I., and Zapater, L. (1996). Adaptación de un instrumento de evaluación de la insatisfacción corporal (BSQ). *Clín. Salud* 8, 51–66.

Ridgway, J. L., and Clayton, R. B. (2016). Instagram unfiltered: exploring associations of body image satisfaction, Instagram# selfie posting, and negative romantic relationship outcomes. *Cyberpsychol., Behav. Soc. Netw.* 19, 2–7. doi: 10.1089/cyber.2015.0433

Rodgers, R. F., McLean, S. A., and Paxton, S. J. (2015). Longitudinal relationships among internalization of the media ideal, peer social comparison, and body dissatisfaction: Implications for the tripartite influence model. *Dev. Psychol.* 51, 706–713. doi: 10.1037/dev0000013

Rosen, J. C. (1992). Eating disorders: pulling it all together. *Psyccritiques* 37, 792–793. doi: 10.1037/032464

Roses-Gómez, M. R. (2014). *Desarrollo y Evaluación de la Eficacia de Dos Programas Preventivos en Comportamientos no Saludables Respecto al Peso y la Alimentación*. Estudio piloto Doctoral Thesis. Universidad Autónoma de Barcelona, Barcelona.

Sabik, N., and Versey, H. S. (2016). Functional limitations, body perceptions, and health outcomes among older African American women. *Cult. Divers. Ethnic Minor. Psychol.* 22, 594–601. doi: 10.1037/cdp0000106

Sánchez, V., Muñoz-Fernández, N., and Ortega-Ruíz, R. (2015). "Cyberdating Q_A": an instrument to assess the quality of adolescent dating relationships in social networks. *Comput. Hum. Behav.* 48, 78–86. doi: 10.1016/j.chb.2015.01.006

Sánchez-Cabrero, R. (2012). *IMAGINA: Programa de Mejora de la Autoestima y la Imagen Corporal Para Adultos*. Logroño: Sinindice.

Sánchez-Cabrero, R., Carranza-Herrezuelo, N., Novillo-López, M. A., and Pericacho-Gómez, F. J. (2019). The importance of physical appearance during the ageing process in Spain. Interrelation between Body and Life Satisfaction during Maturity and the Old Age. *Activit. Adapt. Aging* 43, 1–15. doi: 10.1080/01924788.2019.1651187

Sánchez-Cabrero, R., and Maganto, C. (2009). Satisfacción corporal y vital de personas mayores de 50 años en España. *Revista de Psicología General y Aplicada* 62, 293–302.

Swami, V., Barron, D., and Furnham, A. (2018). Exposure to natural environments, and photographs of natural environments, promotes more positive body image. *Body Image* 24, 82–94. doi: 10.1016/j.bodyim.2017.12.006

Thompson, J. K. (ed.) (2004). *Handbook of Eating Disorders and Obesity*. Hoboken, NJ: John Wiley and Sons Inc.

Tiggemann, M. (2004). Body image across the adult life span: Stability and change. *Body Image* 1, 29–41. doi: 10.1016/S1740-1445(03)00002-0

Tylka, T. L., and Homan, K. J. (2015). Exercise motives and positive body image in physically active college women and men: Exploring an expanded acceptance model of intuitive eating. *Body Image* 15, 90–97. doi: 10.1016/j.bodyim.2015.07.003

Tylka, T. L., and Wood-Barcalow, N. L. (2015). What is and what is not positive body image? Conceptual foundations and construct definition. *Body Image* 14, 118–129. doi: 10.1016/j.bodyim.2015.04.001

Vega, A. V., Ramos, L. M., Barrios, M. L., and Quintero, M. V. (2015). Imagen del cuerpo en adultos mayores. *Salud En Movimiento* 7, 4–10.

Webster, J., and Tiggemann, M. (2003). The relationship between women's body satisfaction and self-image across the life span: The role of cognitive control. *J. Genet. Psychol.* 164, 241–252. doi: 10.1080/00221320309597980

World Medical Association, (2013). *WMA Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects*. France: World Medical Association

Zdenko, Z., and Geiger-Zeman, M. (2015). Young. Heart in "Old" Body. *Exp. Ageing Older Persons' Perspect.* 45, 72–85. doi: 10.15378/1848-9540.2015.38.03

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The Representation of Body Size: Variations With Viewpoint and Sex

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Perceived body size is a fundamental construct that reflects our knowledge of self and is important for all aspects of perception, yet how we perceive our bodies and how the body is represented in the brain is not yet fully understood. In order to understand how the brain perceives and represents the body, we need an objective method that is not vulnerable to affective or cognitive influences. Here, we achieve this by assessing the accuracy of full-body size perception using a novel psychophysical method that taps into the implicit body representation for determining perceived size. Participants were tested with life-size images of their body as seen from different viewpoints with the expectation that greater distortions would occur for unfamiliar views. The Body Shape Questionnaire was also administered. Using a two-alternative forced choice design, participants were sequentially shown two life-size images of their whole body dressed in a standardized tight-fitting outfit seen from the front, side, or back. In one image, the aspect ratio (with the horizontal or vertical dimension fixed) was varied using an adaptive staircase, while the other was undistorted. Participants reported which image most closely matched their own body size. The staircase honed in on the distorted image that was equally likely as the undistorted photo to be judged as matching their perception of themselves. From this, the perceived size of their internal body representation could be calculated. Underestimation of body width was found when the body was viewed from the front or back in both sexes. However, females, but not males, overestimated their width when the body was viewed from the side. Height was perceived accurately in all views. These findings reveal distortions in perceived size for healthy populations and show that both viewpoint and sex matter for the implicit body representation. Though the back view of one's body is rarely–if ever–seen, perceptual distortions were the same as for the front view. This provides insight into how the brain might construct its representation of three-dimensional body shape.

Keywords: body representation, perceived size, full body perception, viewpoint, perceptual size distortions, height, body width

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INTRODUCTION

The body is such an important part of our life – without it, we would not even exist. We use our body to present ourselves and to perceive and interact in the world. Knowledge about body posture, position, size, and structure are required to interpret and react to sensory information that is constantly being received and that may be coded relative to the body (Kopinska and Harris, 2003; Harris et al., 2015). Processing sensations and generating actions requires the brain to accurately map and represent the body and the body-in-space. However, the first-person perspective of the body is highly restricted, and the third-person perspective afforded by a mirror provides only a limited view. We cannot directly see our entire body in the same way that we can view the entirety of our hands, arms, and legs. However, it is the full three-dimensional body that is represented in the brain (Kammers et al., 2009; Longo and Haggard, 2012). How is the brain able to form such a representation of the body when it is not able to see it from multiple viewpoints? How accurate is its representation? The question then becomes focused on body perception when seen in unfamiliar views, such as from the side or back, to better understand how the implicit body representation is built up in the brain. We aim to answer these questions by assessing how accurate people are at judging their full body size when viewing their body from various viewpoints of which only the frontal view would be familiar. We used our novel psychophysical method that provides an implicit measure of the internal body representation (D'Amour and Harris, 2017). Our method involves a participant choosing which of two images is most like their own body and adjusting one of the images accordingly. It ends when both images (reference and distorted) are equally likely to be chosen, neither of which actually matches their body representation. The representation is calculated as being between these values.

Body size perception has typically been looked at in those suffering from eating disorders as distortions and disturbances of perceived body size and shape most obviously occur in these populations (Molinari, 1995; Probst et al., 1995; Gardner and Brown, 2014). Such studies have often tended to focus on measuring body image – how one feels about one's body from a cognitive, emotional, and subjective view – rather than looking at how the brain internally maps and represents the body.

The objective of the current study was to examine perceived full body size accuracy to determine baseline values of how distorted the brain's representation might be in a healthy, young populations of both males and females. The perceived width and height of the full body was measured as seen from three different body viewpoints in order to assess how the accuracy of perception changes when the image is presented in familiar and unfamiliar views. Previous studies have suggested both men and women tend to overestimate body width (e.g., Dolan et al., 1987; Stephen et al., 2018) and have emphasized the importance of baseline judgments in the healthy population (Sadibolova et al., 2019). However, until the introduction of virtual avatars, most studies have used smaller-than-life-size photographs, which confound absolute judgments with aspect ratio judgments and perhaps explain why perceived height, which requires the use of full-size images, has been neglected. Estimates of people's perception of their height have tended to come from actions, such as ducking under barrier (Stefanucci and Geuss, 2012) which may not correspond to perceptual measures. In photographs height tends to be underestimated (Kato and Higashiyama, 1998). We hypothesized that there would be significant deviations from accurate in our healthy population, with the body being perceived as bigger and also as shorter than its actual size, with greater distortions for body width.

There is a trend in this area of research to use images of the body as seen from the front – corresponding to the view most commonly seen in the mirror. However, being overweight is most obvious in the profile view: a view which can only be imagined without a complex arrangement of mirrors. There is thus a potential for a richer source of information from judgments of the body seen in side view (Swami and Tovée, 2007; Cohen et al., 2015a,b). We therefore predicted that there would be a difference between viewpoints. Familiar views (as seen in a mirror) were expected to be more accurate than unfamiliar views (side and back views that rely on a person's imagination to visualize), so that the front view would be the most accurate and the back and side views would be the least accurate.

Sex and body satisfaction were also assessed to see how these factors might impact perceived body size. Men and women show different patterns of perceived body distortion with women being more prone to judge themselves as fatter (Fallon and Rozin, 1985). This asymmetry may even have a basis in the differential roles of the cortical hemispheres in the representation of the body (Mohr et al., 2007). Differences related to both sex and body satisfaction were therefore anticipated, with females and those with higher levels of body dissatisfaction showing greater perceptual distortions. Previous studies looking at body size perception have tended to concentrate on females (e.g., Slade and Russell, 1973; Gleghorn et al., 1987; Thompson and Spana, 1988; Molinari, 1995; Cornelissen et al., 2017; but see Dolan et al., 1987; Craig and Caterson, 1990). Thus, there is a relative lack of knowledge about how males represent their bodies and whether they might also show distortions in size perception. Here, we included both males and females. While previous research has shown that perceptual body distortions occur more in those dissatisfied with their bodies (e.g., Cash and Deagle, 1997; Probst et al., 1998; Stice and Shaw, 2002; Hrabosky et al., 2009; Mohr et al., 2011; Sand et al., 2011; Cornelissen et al., 2013; Mai et al., 2015), these studies have also focused on clinical eating disorder populations with high levels of body dissatisfaction and have often overlooked the healthy population. Based on these previous findings, we thought that there would be differences between low and high body dissatisfaction groups. We expected to find greater distortions for those in the high body dissatisfaction group, especially for the width conditions than for those in the low body dissatisfaction group. We also predicted that there would be strong positive correlations between body dissatisfaction and perceived size distortions.

MATERIALS AND METHODS

Participants

Thirty-seven participants (18 females and 19 males) took part in the experiment (mean age = 21.24 years, SD = 7.61; mean BMI = 23.75, SD = 4.09; mean weight = 68.94 kg, SD = 14.39 kg; mean height = 169.93 cm, SD = 7.52 cm; mean Body Shape Questionnaire (BSQ) = 85.27, SD = 33.15). They were recruited from the York University Undergraduate Research Participant

Pool and received course credit for taking part in the study. The protocol was approved by the York Ethics Board. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

Materials/Stimuli

Body Dissatisfaction

The Body Shape Questionnaire (BSQ) (Cooper et al., 1987) is a 34-item self-report questionnaire that was developed to assess concerns about body shape and experiences of feeling fat that participants may have experienced within the previous month. The test was administered before the experiment began to obtain a measure of body dissatisfaction. Higher scores indicate higher levels of body dissatisfaction. Participants were divided into high and low groups defined as whether their scores were above or below the overall mean score.

Photographs

Color photographs of each participant's whole body in standardized poses were taken using a digital camera (Canon EOS 10D; flash on; no zoom function) from each of three different viewpoints with a camera distance of 270 cm. Participants were asked to stand in front of a white wall in three standardized poses. Standardized outfits were provided to obtain accurate outlines of their size and shape (see **Figure 1**). The images were then corrected for any lens distortions, cropped to include only the whole body, and formatted on a white background (Adobe Photoshop CC 2014). These images served as the undistorted reference images and were used for composing distorted images. Actual body height was measured from the bottom of the feet to the top of the head using a ruler taped up to a wall. The image was presented life-size projected (using a BenQ 1080p short throw projector) onto a screen at a viewing distance of 270 cm by digitally adjusting the magnification of the image until it physically matched the participant's actual body size. The viewing distance was chosen as matching the camera's focal length multiplied by the magnification (Cooper et al., 2012), which minimizes distortions.

Distorting the Images

Images were presented and distorted using MATLAB (version 2011b) and Psychophysics Toolbox (Brainard, 1997) running on a MacBook Pro. One dimension of the image (either width – see **Figure 2A** – or length – see **Figure 2B**) was distorted (made either bigger or smaller) using a QUEST adaptive staircase psychometric procedure (Watson and Pelli, 1983). The image was viewed in the center of a projector screen with the full body shown from one of three viewpoints: (1) front, (2) side, or (3) back. Perceived width and height were measured separately for each viewpoint so there was a total of six experimental conditions.

Procedure

Participants sat in a chair at a viewing distance of 270 cm from the projector screen. Each trial consisted of two 1.5 s intervals – one interval containing the undistorted image and one interval containing the distorted image presented in a random order – separated by a blank white screen for 1.5 s. Participants identified which interval contained the image that most closely matched their perception of their own body and responded using a two-button computer mouse (left button for first interval and right button for second interval). A QUEST adaptive staircase procedure (Watson and Pelli, 1983) was used with a two-alternative forced choice (2AFC) design to vary the chosen dimension (length or width) of the distorted image (D'Amour and Harris, 2017). Two interleaved QUEST staircases (25 trials per staircase) were used for each condition (50 trials total), with one starting with the manipulated dimension larger than natural and the

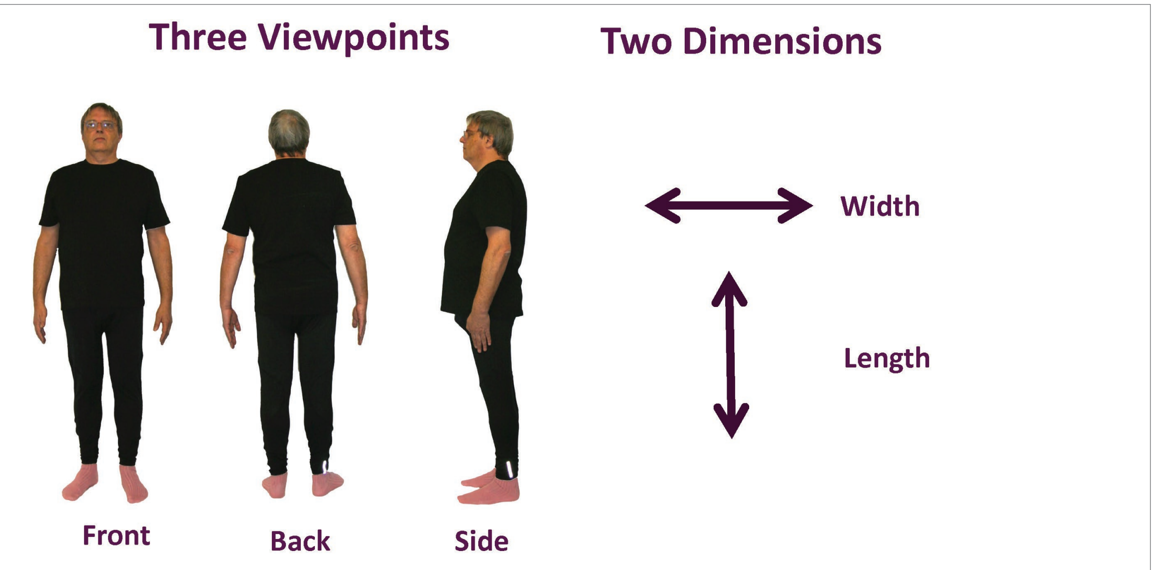

FIGURE 1 | Experimental design and conditions. Sample images of the full body are shown for each viewpoint: front, side, and back. Width and length dimensions (indicated on the right of the figure) were distorted separately for each of the three viewpoints.

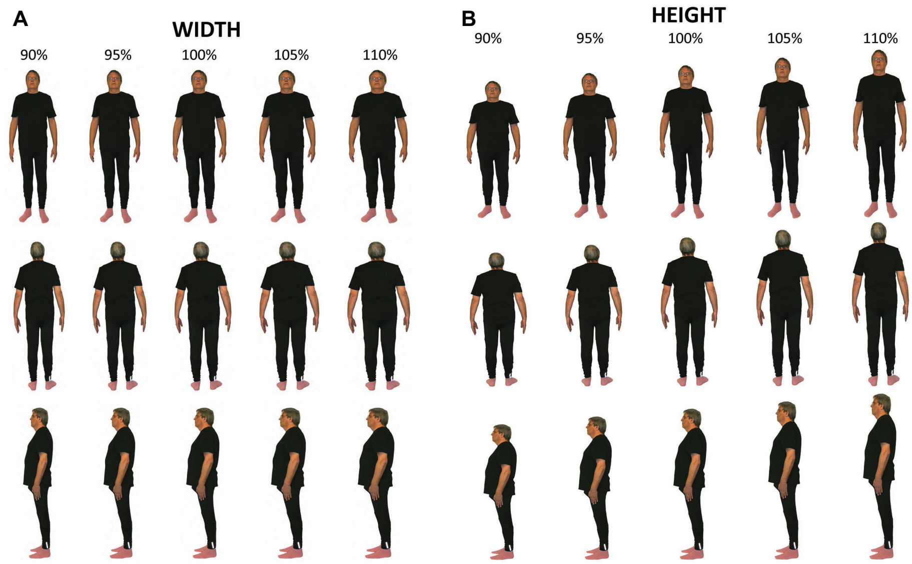

FIGURE 2 | Examples of distorted images. Sample images of the distorted full body are shown for the **(A)** width and **(B)** height for each viewpoint - front, side, and back.

other starting with that dimension smaller than natural. Each of the six conditions was run in a single block and took approximately 6 min to complete. Condition order was determined by a Latin square and was counterbalanced across participants.

Data Analysis

The QUEST program returned an estimate of the percentage distortion relative to the undistorted at which the participant reported that the distorted image was as like their perceived body size as the undistorted image. The QUEST algorithm assumes the observer's psychometric function follows a Weibull distribution and adaptively determines the amount of distortion to be presented based on the participant's response to the previous trials. As the experiment goes on, knowledge on the observer's psychometric accumulates. Participant's decisions were plotted against the distortion used for each trial and fitted with a logistic (Equation 1) using the curve fitting toolbox in MATLAB.

$$\text{Decision} = 1/(1 + \exp(-(x - x_0)/b)) \quad (1)$$

where x_0 is the distorted value that was equally likely to be judged as matching the observer's size as the undistorted photograph, and b is an estimate of the slope of the function. The size of the internal body representation was taken as the point half way between x_0 and the accurate size. We then subtracted 100% from this value to derive a difference-from-accurate score where positive numbers corresponded to an overestimate and negative numbers to an underestimate. The values so obtained for each participant for each condition were examined for outliers, defined as falling outside ±3 standard deviations from the mean. If a value fell outside this range (three participants—two females and one male), the complete dataset for that participant was removed.

One-sample *t*-tests were conducted for each condition to assess whether difference-from-accurate values significantly differed from zero (accurate). Mixed measures analyses of variances (ANOVAs) were used for statistical analyses, with alpha set at $p < 0.05$ and *post hoc* multiple comparisons were made using Bonferroni corrections. Pearson correlations were used to determine the relationship between body dissatisfaction and accuracy. Since we had predicted that there would be a specific direction for the correlations, one-tailed *p*'s were used.

RESULTS

Full Body Size Accuracy

Table 1 summarizes the results of *t*-tests showing that the perceived width when seen from the front and side viewpoints were significantly different from accurate.

Full Body Size Accuracy: Width Dimension

A three-way mixed ANOVA was conducted to test for within-subject effects of viewpoint (front, side, and back), and between-subject effects of sex (male and female) and BSQ group (low and high) for the width dimension (**Figure 3**). A significant main effect of viewpoint, $F(2, 60) = 3.38$, $p = 0.040$, $\eta_p^2 = 0.101$, and a significant interaction between viewpoint and sex, $F(2, 60) = 3.77$, $p = 0.028$, $\eta_p^2 = 0.112$, were revealed. There was a difference in how width was perceived for the side view, with females showing greater overestimation from the side compared to both the front ($p = 0.017$) and back ($p = 0.006$) views with no significant difference between front and back views. Females' side view estimates differed from male side view estimates ($p = 0.019$) with males underestimating their width in side

TABLE 1 | One-sample *t*-tests comparing mean accuracy errors (percentage distortions) to accurate (zero distortion).

	M (SEM)	*t*(33)	*p*	95% CI
Width				
Front	−3.15 ± 1.32	−2.39	0.023*	[−5.84, −0.46]
Side	−0.83 ± 1.29	−0.64	0.524	[−3.45, 1.79]
Back	−2.85 ± 1.14	−2.49	0.018*	[−5.18, −0.52]
Length				
Front	−0.71 ± 0.87	−0.82	0.420	[−2.47, 1.05]
Side	−0.07 ± 0.87	−0.08	0.934	[−1.85, 1.71]
Back	0.34 ± 0.91	0.37	0.714	[−1.51, 2.18]

SEM, standard error of the mean; CI, confidence interval.
*N = 34. *p < 0.05.*

view and females overestimating it. No interaction effects were found between viewpoint and BSQ group, $F(2, 60) = 0.90$, $p = 0.413$, $\eta_p^2 = 0.029$, or between viewpoint, sex, and BSQ group, $F(2, 60) = 0.56$, $p = 0.576$, $\eta_p^2 = 0.018$. There were no significant findings in any of the between-subjects effects tests.

Full Body Size Accuracy: Length (Height) Dimension

A second ANOVA was conducted using the same variables as above for the length (height) dimension (**Figure 4**). No significant main effects or interactions were found for the within-subjects effects tests. This suggests that perceived body length (height) was not impacted by seeing the body in different views. However, there was a significant interaction between sex and BSQ group, $F(1, 30) = 7.51$, $p = 0.010$, $\eta_p^2 = 0.200$. The high BSQ group differed ($p = 0.026$) in the distortion direction for males (overestimate: $M = 2.71$, SE = 1.72) and females (underestimate: $M = -2.59$, SE = 1.46). There were also non-significant trends when the high and low BSQ groups were compared for each sex (males: $p = 0.075$; females: $p = 0.051$).

Correlations Between Perceived Full Body Size Accuracy and Body Shape Questionnaire Scores

Pearson correlations were run on the BSQ scores and differences-from-accurate to determine the relationship between body dissatisfaction and perceived size judgments. For the width dimension (**Figure 5**), there was a strong and significant correlation for the front view, $r(33) = 0.310$, $p = 0.037$, and the side view, $r(33) = 0.349$, $p = 0.022$, but no relationship was found for the back view, $r(33) = 0.099$, $p = 0.289$. There were no significant correlations between perceived size accuracy and BSQ score for the length (height) dimension [front: $r(33) = -0.193$, $p = 0.138$; side: $r(33) = -0.077$, $p = 0.333$; back: $r(33) = -0.100$, $p = 0.287$].

Discussion

Width and length were measured for the full body from the front, side, and back view in order to obtain baseline accuracy

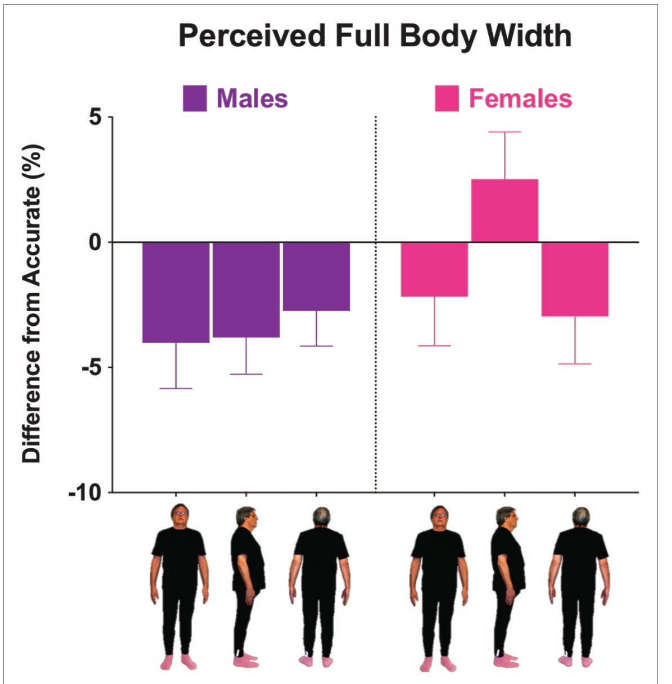

FIGURE 3 | Mean differences from accurate for males (**left panel**) and females (**right panel**) when body width was distorted for each viewpoint. Positive and negative scores represent overestimation and underestimation, respectively. Error bars represent ±1 SEM.

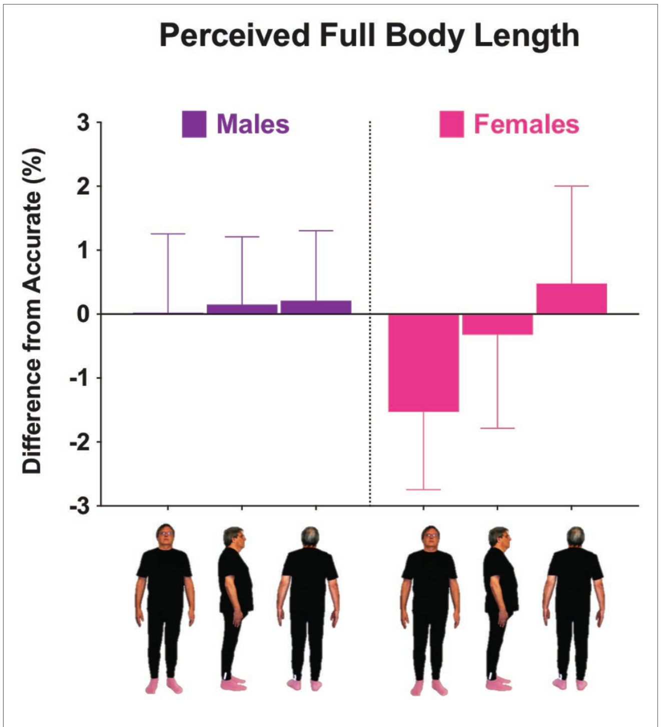

FIGURE 4 | Mean differences from accurate for males (**left panel**) and females (**right panel**) when body length (height) was distorted for each viewpoint. Positive and negative scores represent overestimation and underestimation, respectively. Error bars represent ±1 SEM.

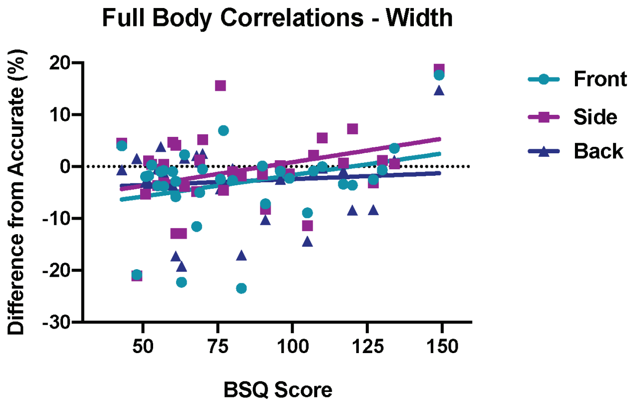

FIGURE 5 | Correlations between BSQ score and differences from accurate for perceived body width for the front (blue circles), side (purple squares), and back (dark blue triangles) viewpoints (n = 34). The solid lines through the data represent linear regression fits.

values in a healthy population of males and females. We found that the full body was perceived as thinner (underestimating width) in the front and back views but when the body was viewed from the side, only females overestimated their width. A parallel can be found in emerging sex differences in hand perception where overestimation of hand width is larger in females (Coelho and Gonzalez, 2019; Longo, 2019). The height of the body was perceived as accurate. Our results reveal that viewpoint, sex, dimension (height/width), and body satisfaction matter for body representation. These findings provide insights into the mechanisms and factors that are involved in understanding how the body is processed, represented, and perceived.

Overall Accuracy

Our finding that, independent of sex or body dissatisfaction, full body size was perceived as different from actual size when viewed from the front and side view when measured using a rigorous psychophysical method, is a novel finding that adds to the literature about body size accuracy in healthy populations. These results provide baseline measurements of distortions in full body perception at the level of the brain's implicit body representation. The underestimations in body width that we observed have also been shown in some previous studies (e.g., Gardner et al., 1989). The finding that height was perceived accurately in all cases was unexpected because we make continual changes and adjustments to alter the height of our bodies at least as perceived by others such as by wearing heeled shoes, donning hats, and often by styling our hair. A unique feature of this study was that we used life-size photographs which are necessary to measure perceived height. While previous studies have looked at height estimation, they have typically used methods that require participants to make judgments based on apertures or barriers (e.g., Stefanucci and Geuss, 2012; Wignall et al., 2017), but these indirect measures cannot be applied to understanding the accuracy of the internal representation of body height.

The Effect of Viewpoint

Front and Back View

Our predictions about the effects of viewpoint turned out to be the opposite of what we found. There was a general tendency to underestimate body width for males and females in accordance with Mazzurega et al.'s self-serving bias (Mazzurega et al., 2018). Interestingly, the front view (the view that we often see in a mirror) and the back (a view that we never see) showed the same distortions. And instead of familiar views being the most accurate, the front view actually showed the greatest amount of distortions. This may be a further support for the special relationship that the front and back of the body have with each other. The representations of the front and back of the body may be mapped together by the brain (Parsons and Shimojo, 1987; D'Amour and Harris, 2014; Harris et al., 2015; Hoover and Harris, 2015; Tamè et al., 2016). Thus, any distortion of one would be reflected in a comparable distortion of the other (see **Figure 3**).

Side View

Females perceived themselves to be wider than actual size only in the side view reminiscent of the female-only "fatter bias" of Mohr et al. (2007). There are several possible reasons for this. The side view is rarely if ever seen and therefore is most demanding on the viewer's ability to visualize this view using only their internal representation. It may therefore be the best view with which to measure the size of this representation (Cohen et al., 2015a) and the one most able to reveal true distortions. We confirmed that, in this view, women are more likely than men to see themselves as fatter (Fallon and Rozin, 1985), but why might this be the case? Could this be due to the structure and functionality of a woman's body? We did not ask whether any of our participants had been through pregnancy, and their youthfulness suggests that it would have been rare, but the potential for pregnancy involves an explicit expectation of flexibility in this front/back dimension (Franchak and Adolph, 2014). We speculate that this flexibility and the expectation of future expansion in this dimension, not expected by men, may underlie this sex difference. Another possible explanation is that females may have acquired a general tendency to see themselves as fatter than they really are – an illusion encouraged by any amount of advertising campaigns and the media (Thompson and Mikellidou, 2011; Docteur et al., 2012; Shin and Baytar, 2013; Gledhill et al., 2019). Hashimoto and Iriki (2013) found that slightly slimmer body images were most desirable as own-body images and that this tendency is most pronounced in women (Cazzato et al., 2012).

Another study (Cornelissen et al., 2018) aimed to determine which orientation was best for body size estimation tasks responding to the lack of research on how different viewpoints affect accuracy in body mass judgments. Since the majority of research has only presented the body from the front view, it is unclear whether this is the optimal viewpoint or if important visual cues that people use for size judgments are being obscured, such as stomach depth (Tovée et al., 1999; Smith et al., 2007;

Rilling et al., 2009) and thickness of the thighs and buttocks (Cornelissen et al., 2009, 2016; Cohen et al., 2015a,b). While their study used computer-generated generic images and did not ask for own-body size judgments, they found a loss in precision for front view stimuli compared to both three-quarter and side views (Cornelissen et al., 2018) which supports our current findings.

Sex and Body Satisfaction Scores

We have shown that distortions exist in both sexes for both low and high body dissatisfaction groups. Although there was surprisingly no effect of BSQ group on perceived width, there was a difference for perceived height between the males and females that were more dissatisfied with their bodies. On average across all three viewpoints, males in the high BSQ group perceived an increase in height, whereas females perceived a decrease. This finding could be due to attitudinal and societal factors that are experienced by each sex. When the relationship between BSQ score and perceived size accuracy was examined, it was revealed that higher body dissatisfaction showed greater distortions in perceived width for the front and side views. This is in agreement with Mazzurega et al. (2018) who related such findings to body attractiveness and what they called the self-serving bias. This bias is weaker in people who are less satisfied with their body and may result in greater distortions. It is difficult to compare our findings with previous studies since we used a population of healthy males and females and therefore had a much smaller range of BSQ scores than would be seen in females with eating disorders. Another potential limitation is that our sample size was quite small for conducting correlations and that we had an unequal amount of people in the low and high BSQ groups.

CONCLUSION

Our results are important because they assess the internal representation of body dimensions independent of distortions of the body image. To extend our study and further the research done to gain knowledge about how the brain represents the body, future studies using 3D full body images/avatars should be done with our method to obtain more details about the brain's modeling and mapping of body size, shape, and structure. Other potential research that could be beneficial for comparing and contrasting with our findings (and all previous literature) would be to use our method in different experimental designs, such as testing the effects of image size, distorting both dimensions at once, distorting only particular parts of the full body, or testing a greater range of viewpoints. Findings from such lines of research could be used to develop programs to retune body representations not only in clinical populations but also for athletes and dancers where accurate body representation is particularly critical.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the York Ethics Board. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

SD'A conceived the study and designed the experimental methodology. SD'A and LH devised and created the experimental methods, stimuli, and programming. SD'A performed the experiment and collected the data. SD'A analyzed the data and drafted the manuscript. Both authors contributed to the writing of the paper.

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REFERENCES

Brainard, D. H. (1997). The psychophysics toolbox. *Spat. Vis.* 10, 433–436. doi: 10.1163/156856897X00357

Cash, T. F., and Deagle, E. A. (1997). The nature and extent of body-image disturbances in anorexia nervosa and bulimia nervosa: a meta-analysis. *Int. J. Eat. Disord.* 22, 107–125. doi: 10.1002/(SICI)1098-108X(199709)22:2<107::AID-EAT1>3.0.CO;2-J

Cazzato, V., Siega, S., and Urgesi, C. (2012). "What women like": influence of motion and form on esthetic body perception. *Front. Psychol.* 3, 1–10. doi: 10.3389/fpsyg.2012.00235

Coelho, L. A., and Gonzalez, C. L. R. (2019). Chubby hands or little fingers: sex differences in hand representation. *Psychol. Res.* 83, 1375–1382. doi: 10.1007/s00426-018-1003-x

Cohen, E., Bernard, J. Y., Ponty, A., Ndao, A., Amougou, N., Saïd-Mohamed, R., et al. (2015a). Development and validation of the body size scale for assessing body weight perception in African populations. *PLoS One* 10, 1–14. doi: 10.1371/journal.pone.0138983

Cohen, E., Ndao, A., Boëtsch, G., Gueye, L., Pasquet, P., Holdsworth, M., et al. (2015b). The relevance of the side-view in body image scales for public health: an example from two JAFn populations biostatistics and methods. *BMC Public Health* 15:1169. doi: 10.1186/s12889-015-2511-x

Cooper, P. J., Cooper, M. J., Cooper, Z., and Fairburn, C. G. (1987). The development and validation of the Body Shape Questionnaire. *Int. J. Eat. Disord.* 6, 485–494. doi: 10.1002/1098-108X(198707)6:4<485::AID-EAT2260060405>3.0.CO;2-O

Cooper, E. A., Piazza, E. A., and Banks, M. S. (2012). The perceptual basis of common photographic practice. *J. Vis.* 12:8. doi: 10.1167/12.5.8

Cornelissen, P. L., Cornelissen, K. K., Groves, V., McCarty, K., and Tovée, M. J. (2018). View-dependent accuracy in body mass judgements of female bodies. *Body Image* 24, 116–123. doi: 10.1016/j.bodyim.2017.12.007

Cornelissen, K. K., Gledhill, L. J., Cornelissen, P. L., and Tovée, M. J. (2016). Visual biases in judging body weight. *Br. J. Health Psychol.* 21, 555–569. doi: 10.1111/bjhp.12185

Cornelissen, P. L., Johns, A., and Tovée, M. J. (2013). Body size over-estimation in women with anorexia nervosa is not qualitatively different from female controls. *Body Image* 10, 103–111. doi: 10.1016/j.bodyim.2012.09.003

Cornelissen, K. K., McCarty, K., Cornelissen, P. L., and Tovée, M. J. (2017). Body size estimation in women with anorexia nervosa and healthy controls using 3D avatars. *Sci. Rep.* 7, 1–15. doi: 10.1038/s41598-017-15339-z

Cornelissen, P. L., Toveé, M. J., and Bateson, M. (2009). Patterns of subcutaneous fat deposition and the relationship between body mass index and waist-to-hip ratio: implications for models of physical attractiveness. *J. Theor. Biol.* 256, 343–350. doi: 10.1016/j.jtbi.2008.09.041

Craig, P. L., and Caterson, I. D. (1990). Weight and perceptions of body image in women and men in a Sydney sample. *Community Health Stud.* 14, 373–383. doi: 10.1111/j.1753-6405.1990.tb00048.x

D'Amour, S., and Harris, L. R. (2014). Vibrotactile masking through the body. *Exp. Brain Res.* 232, 2859–2863. doi: 10.1007/s00221-014-3955-4

D'Amour, S., and Harris, L. R. (2017). Perceived face size in healthy adults. *PLoS One* 12:e0177349. doi: 10.1371/journal.pone.0177349

Docteur, A., Urdapilleta, I., and Rico Duarte, L. (2012). The role of cognitive factors in body-size perception and recall-size estimation in normal-weight women. *Rev. Eur. Psychol. Appl.* 62, 129–135. doi: 10.1016/j.erap.2012.05.001

Dolan, B. M., Birtchnell, S. A., and Lacey, J. H. (1987). Body image distortion in non-eating disordered women and men. *J. Psychosom. Res.* 31, 513–520. doi: 10.1016/0022-3999(87)90009-2

Fallon, A. E., and Rozin, P. (1985). Sex differences in perceptions of desirable body shape. *J. Abnorm. Psychol.* 94, 102–105. doi: 10.1037/0021-843X.94.1.102

Franchak, J. M., and Adolph, K. E. (2014). Gut estimates: pregnant women adapt to changing possibilities for squeezing through doorways. *Atten. Percept. Psychophys.* 76, 460–472. doi: 10.3758/s13414-013-0578-y

Gardner, R. M., and Brown, D. L. (2014). Body size estimation in anorexia nervosa: a brief review of findings from 2003 through 2013. *Psychiatry Res.* 219, 407–410. doi: 10.1016/j.psychres.2014.06.029

Gardner, R. M., Morrell, J. A., Watson, D. N., and Sandoval, S. L. (1989). Subjective equality and just noticeable differences in body-size judgments by obese persons. *Percept. Mot. Skills* 69, 595–604. doi: 10.2466/pms.1989.69.2.595

Gledhill, L. J., George, H. R., and Tovée, M. J. (2019). Perceptual not attitudinal factors predict the accuracy of estimating other women's bodies in both women with anorexia nervosa and controls. *Front. Psychol.* 10:997. doi: 10.3389/fpsyg.2019.00997

Gleghorn, A. A., Penner, L. A., Powers, P. S., and Schulman, R. (1987). The psychometric properties of several measures of body image. *J. Psychopathol. Behav. Assess.* 9, 203–218. doi: 10.1007/BF00960575

Harris, L. R., Carnevale, M. J., D'Amour, S., Fraser, L. E., Harrar, V., Hoover, A. E. N., et al. (2015). How our body influences our perception of the world. *Front. Psychol.* 6:819. doi: 10.3389/fpsyg.2015.00819

Hashimoto, T., and Iriki, A. (2013). Dissociations between the horizontal and dorsoventral axes in body-size perception. *Eur. J. Neurosci.* 37, 1747–1753. doi: 10.1111/ejn.12187

Hoover, A. E. N., and Harris, L. R. (2015). The role of the viewpoint on body ownership. *Exp. Brain Res.* 233, 1053–1060. doi: 10.1007/s00221-014-4181-9

Hrabosky, J. I., Cash, T. F., Veale, D., Neziroglu, F., Soll, E. A., Garner, D. M., et al. (2009). Multidimensional body image comparisons among patients with eating disorders, body dysmorphic disorder, and clinical controls: a multisite study. *Body Image* 6, 155–163. doi: 10.1016/j.bodyim.2009.03.001

Kammers, M. P., Longo, M. R., Tsakiris, M., Dijkerman, H. C., and Haggard, P. (2009). Specificity and coherence of body representations. *Perception* 38, 1804–1820. doi: 10.1068/p6389

Kato, K., and Higashiyama, A. (1998). Estimation of height for persons in pictures. *Percept. Psychophys.* 60, 1318–1328. doi: 10.3758/BF03207994

Kopinska, A., and Harris, L. R. (2003). Spatial representation in body coordinates: evidence from errors in remembering positions of visual and auditory targets after active eye, head, and body movements. *Can. J. Exp. Psychol.* 57, 23–37. doi: 10.1037/h0087410

Longo, M. R. (2019). Sex differences in perceptual hand maps: a meta-analysis. *Acta Psychol.* 196, 1–10. doi: 10.1016/j.actpsy.2019.03.002

Longo, M. R., and Haggard, P. (2012). A 2.5-D representation of the human hand. *J. Exp. Psychol. Hum. Percept. Perform.* 38, 9–13. doi: 10.1037/a0025428

Mai, S., Gramann, K., Herbert, B. M., Friederich, H. C., Warschburger, P., and Pollatos, O. (2015). Electrophysiological evidence for an attentional bias in processing body stimuli in bulimia nervosa. *Biol. Psychol.* 108, 105–114. doi: 10.1016/j.biopsycho.2015.03.013

Mazzurega, M., Marisa, J., Zampini, M., and Pavani, F. (2018). Thinner than yourself: self-serving bias in body size estimation. *Psychol. Res.* doi: 10.1007/s00426-018-1119-z [Epub ahead of print].

Mohr, C., Porter, G., and Benton, C. P. (2007). Psychophysics reveals a right hemispheric contribution to body image distortions in women but not men. *Neuropsychologia* 45, 2942–2950. doi: 10.1016/j.neuropsychologia.2007.06.001

Mohr, H. M., Röder, C., Zimmermann, J., Hummel, D., Negele, A., and Grabhorn, R. (2011). Body image distortions in bulimia nervosa: investigating body size overestimation and body size satisfaction by fMRI. *NeuroImage* 56, 1822–1831. doi: 10.1016/j.neuroimage.2011.02.069

Molinari, E. (1995). Body-size estimation in anorexia nervosa. *Percept. Mot. Skills* 81, 23–31.

Parsons, L. M., and Shimojo, S. (1987). Perceived spatial organization of cutaneous patterns on surfaces of the human body in various positions. *J. Exp. Psychol. Hum. Percept. Perform.* 13, 488–504. doi: 10.1037/0096-1523.13.3.488

Probst, M., Vandereycken, W., Van Coppenolle, H., and Pieters, G. (1995). Body size estimation in eating disorder patients: testing the video distortion method on a life-size screen. *Behav. Res. Ther.* 33, 985–990. doi: 10.1016/0005-7967(95)00037-X

Probst, M., Vandereycken, W., Van Coppenolle, H., and Pieters, G. (1998). Body-size estimation in anorexia nervosa patients: the significance of overestimation. *J. Psychosom. Res.* 44, 451–456. doi: 10.1016/S0022-3999(97)00270-5

Rilling, J. K., Kaufman, T. L., Smith, E. O., Patel, R., and Worthman, C. M. (2009). Abdominal depth and waist circumference as influential determinants of human female attractiveness. *Evol. Hum. Behav.* 30, 21–31. doi: 10.1016/j.evolhumbehav.2008.08.007

Sadibolova, R., Ferrè, E. R., Linkenauger, S. A., and Longo, M. R. (2019). Distortions of perceived volume and length of body parts. *Cortex* 111, 74–86. doi: 10.1016/j.cortex.2018.10.016

Sand, L., Lask, B., Høie, K., and Stormark, K. M. (2011). Body size estimation in early adolescence: factors associated with perceptual accuracy in a nonclinical sample. *Body Image* 8, 275–281. doi: 10.1016/j.bodyim.2011.03.004

Shin, E., and Baytar, F. (2013). Apparel fit and size concerns and intentions to use virtual try-on: impacts of body satisfaction and images of models' bodies. *Cloth. Text. Res. J.* 32, 20–33. doi: 10.1177/0887302X13515072

Slade, P. D., and Russell, G. F. M. (1973). Awareness of body dimensions in anorexia nervosa: cross-sectional and longitudinal studies. *Psychol. Med.* 3, 188–199. doi: 10.1017/S0033291700048510

Smith, K. L., Cornelissen, P. L., and Tovée, M. J. (2007). Color 3D bodies and judgements of human female attractiveness. *Evol. Hum. Behav.* 28, 48–54. doi: 10.1016/j.evolhumbehav.2006.05.007

Stefanucci, J. K., and Geuss, M. N. (2012). Duck! Scaling the height of a horizontal barrier to body height. *Atten. Percept. Psychophys.* 72, 1338–1349. doi: 10.3758/APP

Stephen, I. D., Sturman, D., Stevenson, R. J., Mond, J., and Brooks, K. R. (2018). Visual attention mediates the relationship between body satisfaction and susceptibility to the body size adaptation effect. *PLoS One* 13, 4–6. doi: 10.1371/journal.pone.0189855

Stice, E., and Shaw, H. E. (2002). Role of body dissatisfaction in the onset and maintenance of eating pathology. A synthesis of research findings. *J. Psychosom. Res.* 53, 985–993. doi: 10.1016/S0022-3999(02)00488-9

Swami, V., and Tovée, M. J. (2007). The relative contribution of profile body shape and weight to judgements of women's physical attractiveness in Britain and Malaysia. *Body Image* 4, 391–396. doi: 10.1016/j.bodyim.2007.07.002

Tamè, L., Braun, C., Holmes, N. P., Farnè, A., Pavani, F., Inserm, U., et al. (2016). Bilateral representations of touch in the primary somatosensory cortex. *Cognit. Neuropsychol.* 33, 48–66. doi: 10.1080/02643294.2016.1159547

Thompson, P., and Mikellidou, K. (2011). Applying the helmholtz illusion to fashion: horizontal stripes won't make you look fatter. *Iperception* 2, 69–76. doi: 10.1068/i0405

Thompson, J. K., and Spana, R. E. (1988). The adjustable light beam method for the assessment of size estimation accuracy: description, psychometric, and normative data. *Int. J. Eat. Disord.* 7, 521–526. doi: 10.1002/1098-108X(198807)7:4<521::AID-EAT2260070410>3.0.CO;2-H

Tovée, M. J., Maisey, D. S., Emery, J. L., and Cornelissen, P. L. (1999). Visual cues to female physical attractiveness. *Proc. R. Soc. B Biol. Sci.* 266, 211–218. doi: 10.1098/rspb.1999.0624

Watson, A., and Pelli, D. (1983). QUEST - a Bayesian adaptive psychophysical method. *Percept. Psychophys.* 33, 113–120. doi: 10.3758/BF03202828

Wignall, S. J., Thomas, N. A., and Nicholls, M. E. R. (2017). Fat or fiction? Effects of body size, eating pathology, and sex upon the body schema of an undergraduate population. *Body Image* 23, 135–145. doi: 10.1016/j.bodyim.2017.09.004

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Is It Possible to Train the Focus on Positive and Negative Parts of One's Own Body? A Pilot Randomized Controlled Study on Attentional Bias Modification Training

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Dysfunctional body- and shape-related attentional biases are involved in the etiology and maintenance of eating disorders (ED). Various studies suggest that women, particularly those with ED diagnoses, focus on negatively evaluated parts of their own body, which leads to an increase in body dissatisfaction. The present study aims to empirically test the hypothesis that non-ED women show an attentional bias toward negative body parts and that the focus on positive and negative parts of one's own body can be modified by attentional bias modification training based on a dot-probe task. Although several studies have measured body-related attentional biases by using pictures of participants' own bodies, the approach of investigating attentional bias *via* a dot-probe task while presenting pictures of the participants' own body parts and modifying the biased attention using such pictures is novel. Women (n = 60) rank-ordered 10 parts of their own body regarding their attractiveness. To examine and modify the attentional focus, pictures of the self-defined positive and negative parts of one's own body were presented by means of a dot-probe task. A paired-sample t-test revealed no difference between reaction times to negative compared to positive body parts, indicating no attentional bias toward negative parts of one's own body. A two-way ANOVA revealed a main effect of time for pictures of positive and negative parts of one's own body, with a decrease in reaction times from pre- to post-training. However, there was no significant interaction between time and training condition concerning reaction times to positive and negative body parts. Our findings replicate previous evidence of a balanced attentional pattern regarding one's own body in women without ED diagnoses. However, the dot-probe task failed to modify the attentional focus. As the modifiability of state body image increases with more pronounced body dissatisfaction, the next step would be to test this approach in clinical samples of women with ED diagnoses.

Keywords: attentional bias modification training, dot-probe task, body dissatisfaction, attentional bias, body image

INTRODUCTION

Body image disturbance is a core feature of anorexia and bulimia nervosa according to the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5; American Psychiatric Association, 2013) and plays a significant role in the etiology and maintenance of eating disorders (Westerberg-Jacobson et al., 2010; Stice et al., 2011; Kearney-Cooke and Tieger, 2015). The integrated cognitive-behavioral model of eating disorders (Williamson et al., 2004) posits that overconcern with shape and weight leads to a body- and eating-related negative self-schema, which is activated by body- or food-related cues. The activation of the self-schema, in turn, leads to attentional biases toward negatively evaluated body- and food-related stimuli. These biases give rise to negative cognitive-affective states such as body-related anxiety and dissatisfaction, which, according to the theory, trigger body checking behavior, body avoidance, or purging behavior.

Various studies have confirmed the model's assumption that women with eating disorder symptoms show an attentional bias toward negatively evaluated body- and shape-related stimuli (for a review, see Aspen et al., 2013; Schuck et al., 2018). Within this field of research, the dot-probe task (MacLeod et al., 1986; MacLeod, 2012) is a prominently applied paradigm for investigating attentional biases in eating disorders. In the dot-probe task, two competing disorder-relevant stimuli, i.e., words or pictures with different emotional valence are simultaneously presented on a screen. Subsequently, a target probe is presented at the location of one of the stimuli, to which the participant is prompted to react. Shorter reaction times to the target indicate that the participant's attention was directed toward the target location just before the target appeared. Hence, reaction time is a measure for the participant's attentional focus and provides information about disorder-specific attentional processes (MacLeod et al., 1986).

The clinical relevance of attentional biases toward negative body- and shape-related stimuli has been repeatedly examined (for a review, see Kerr-Gaffney et al., 2019). In their study using the dot-probe task, Gao et al. (2011) found that women with a high degree of body dissatisfaction showed a faster and prolonged visual attention toward weight-associated words compared to women with a low degree of body dissatisfaction. Furthermore, Rieger et al. (1998) reported that patients with anorexia and bulimia nervosa directed their attention toward negatively evaluated body- and shape-related words, as they showed shorter reaction times to theses stimuli compared to neutral and positive stimulus words in a dot-probe task. In accordance with this finding, Shafran et al. (2007) found that women with eating disorder diagnoses showed an attentional bias toward negative eating- and shape-related pictures in a dot-probe task compared to participants in the control group.

In addition to these studies investigating the attentional bias toward negative body- and shape-related stimuli in general, there are several findings that women with eating disorder diagnoses display a biased attention toward their own body. For example, in an experimental analysis using a dot-probe task with pictures of participants' own bodies and pictures of other people's bodies, Blechert et al. (2010) detected shorter reaction times to pictures of one's own body in women with anorexia nervosa diagnoses. Moreover, in an eye-tracking study using pictures of participants' own bodies, Bauer et al. (2017) found that women with anorexia and bulimia nervosa diagnoses displayed an attentional bias toward parts of their own body which were self-evaluated as unattractive. This finding is in line with the results of an eye-tracking study by Tuschen-Caffier et al. (2015), who also showed that women with anorexia and bulimia nervosa diagnoses focused more on subjectively unattractive parts of their own body than on subjectively beautiful body parts. Non-clinical participants, in contrast, showed a more balanced attentional pattern concerning different parts of their own body. In this regard, Jansen et al. (2005) even reported that women without eating disorder diagnoses displayed a self-serving attentional focus regarding their own body, by directing their attention toward subjectively positive body parts rather than toward subjectively negative body parts.

However, contrary to the latter finding, several studies suggest that women without eating disorder diagnoses also display an attentional bias toward negatively valenced parts of their own body. For example, in an eye-tracking study, Roefs et al. (2008) found that non-clinical women displayed an attentional focus on self-defined unattractive body parts. Moreover, Bauer et al. (2017) reported that non-clinical adolescent females showed an attentional bias toward subjectively unattractive parts of their own body. These inconsistent findings might be explained by the assumption of the integrated cognitive-behavioral model of eating disorders (Williamson et al., 2004) that the extent of biased attention is linked to the degree of body dissatisfaction, leading to a more pronounced attentional bias in women with high levels of body dissatisfaction (Roefs et al., 2008; Bauer et al., 2017) compared to women with low levels of body dissatisfaction (Tuschen-Caffier et al., 2015).

Although, as described above, several studies have examined body-related attentional biases using the dot-probe paradigm, there is no research investigating attentional bias toward negatively evaluated parts of one's own body by means of a dot-probe task and employing pictures of the participants' own body parts. Such an approach is important, as the use of pictures of the participants' own body parts might enhance the ecological validity of findings.

As predicted by the integrated cognitive-behavioral model of eating disorders (Williamson et al., 2004), dysfunctional body- and shape-related attentional biases seem to be involved in the development and maintenance of eating disorders (Cash, 2011; Smeets et al., 2011b). Several correlational studies suggest that an attentional bias toward negatively evaluated body-related stimuli leads to an increase in symptoms associated with eating disorders, such as body dissatisfaction, body checking, and body avoidance behavior (for a review, see Lee and Shafran, 2004).

To overcome the limitations of correlational research and to allow for causal inferences, several studies have attempted to examine the effects of attentional bias modification training (ABMT) on eating disorder-related symptoms. In order to induce an attentional bias by means of a modified dot-probe task, in every trial, the target probe appears exclusively at the location of the stimuli to which the participant is trained to attend (MacLeod et al., 2002). Accordingly, to induce an attentional bias toward positive stimuli, the target probe appears exclusively at the location of the positive stimuli, whereas to induce an attentional bias toward negative stimuli, the target probe appears exclusively at the location of the negative stimuli. For example, in a study by Smith and Rieger (2009), non-clinical women were trained to focus on negative shape- and weight-related words in the framework of a modified dot-probe task. The authors found that ABMT toward negative shape- and weight-related words exacerbated body dissatisfaction, while ABMT toward positive or neutral shape- and weight-related words did not. Similarly, in an eye-tracking study, Smeets et al. (2011a) induced an attentional bias toward self-defined attractive and unattractive body parts. Again, after the ABMT on unattractive body parts, a decrease in body satisfaction was observed.

Taken together, the results of these experimental studies indicate that an attentional bias might contribute to the development and maintenance of body dissatisfaction, which is regarded as a manifestation of body image disturbance (Hrabosky et al., 2009). Therefore, ABMT might be a promising interventional approach for increasing body satisfaction and for the treatment of body image disturbance in women with eating disorders.

While in other areas such as anxiety disorder research, there is an abundance of studies on ABMT, albeit with heterogeneous findings (for a review, see Bar-Haim, 2010; Hakamata et al., 2010), only a small number of studies have attempted to modify the attentional bias toward eating disorder-relevant stimuli (Smith and Rieger, 2006, 2009; Werthmann et al., 2014). Moreover, only one experimental study has investigated the effects of ABMT using pictures of participants' own body parts (Smeets et al., 2011a). In this eye-tracking study, non-clinical women were trained to focus on either self-defined attractive or unattractive parts of their own body. For this purpose, a probe was presented on attractive or unattractive body parts of a blurred picture of the participants' body. After detecting the probe, which was measured by an eye tracker, the corresponding body part lit up until the next trial. After the ABMT on subjectively unattractive body parts, self-reported body satisfaction decreased. Correspondingly, subsequent ABMT on attractive body parts led to an increase in body satisfaction. This finding indicates that ABMT might be a promising approach for modulating dysfunctional attentional processes. However, as this study did not use a standard dot-probe paradigm, it remains unclear how its outcome compares to results from this line of ABMT research. Moreover, it can be argued that the presentation of competing body stimuli might increase the ecological validity and generalizability of findings. The simultaneous presentation of competing body parts in the dot-probe task might reflect the participants' experience in daily life, as participants have the opportunity to focus on different parts of their own body.

To sum up, several studies have examined the attentional bias concerning body-related words (Rieger et al., 1998; Gao et al., 2011) or pictures (Shafran et al., 2007; Blechert et al., 2010) using the dot-probe paradigm, but no study has investigated attentional bias toward parts of one's own body by means of a dot-probe task and employing pictures of participants' own body parts. To date, attentional bias toward specific parts of one's own body has been assessed in various eye-tracking studies (Jansen et al., 2005; Roefs et al., 2008; Smeets et al., 2011a; Tuschen-Caffier et al., 2015; Bauer et al., 2017). Moreover, only a small number of studies have attempted to examine the modification of attentional bias *via* ABMT based on a dot-probe task, and these studies used body-related words (Smith and Rieger, 2006, 2009) or food-related pictures (Werthmann et al., 2014) as stimuli. To date, no study investigated the modification of attentional bias toward parts of one's own body by means of a modified dot-probe task and employing pictures of participants' own body parts. Besides, only one eye-tracking study (Smeets et al., 2011a) intended to modify the attentional focus on parts of participants' own body. In addition, no studies have attempted to examine the attentional bias and modify the attentional focus within the framework of a single study. Hence, no previous study has investigated the attentional bias toward negatively valenced parts of one's own body while also examining ABMT by means of a dot-probe task including pictures of participants' own body parts. Therefore, the aim of the present study was to fill this gap by examining whether non-clinical women display an attentional bias toward negatively evaluated parts of their own body within the framework of a dot-probe task. Furthermore, we wished to test whether attentional bias can be modified by ABMT based on a dot-probe task comprising pictures of the participants' own body parts ranked according to different levels of attractiveness. Finally, we sought to investigate whether the degree of body satisfaction changes from pre- to post-ABMT.

For this purpose, 60 non-clinical females underwent the ABMT with 20 participants allocated to each of the following three different training conditions: positive, negative, and control. The positive training condition aimed to induce an attentional bias toward positive parts of one's own body, whereas the negative training condition aimed to induce an attentional bias toward negative parts of one's own body. The control condition did not aim to modify participants' attention. To determine the participants' attentional focus, reaction times to the target probe were measured.

First, we hypothesized that non-clinical women would display an attentional bias toward negatively valenced parts of their own body within the framework of a dot-probe task, as indicated by shorter reaction times to pictures of negatively evaluated body parts compared to reaction times to pictures of positively evaluated body parts. Second, we expected that following ABMT on positively evaluated parts of one's own body, reaction times to pictures of positively evaluated body parts would be shorter compared to ABMT on negatively evaluated body parts and the control condition. Third, we hypothesized that following ABMT on negatively evaluated parts of one's own body, reaction times to pictures of negatively evaluated body parts would be shorter compared to ABMT on positively evaluated body parts and the control condition. Fourth, we expected that the degree of body satisfaction would increase from pre- to post-ABMT in the case of ABMT on positively evaluated parts of one's own body, decrease in the case of ABMT on negatively evaluated parts of one's own body, and remain unchanged in the control condition. Fifth, we hypothesized that the more pronounced the attentional bias before the ABMT, the higher the change in the degree of body dissatisfaction from pre- to post-ABMT.

MATERIALS AND METHODS

Participants

The sample consisted of N = 60 female students from the University of Osnabrück, Germany, who received course credits for their participation in the current study. Inclusion criteria were female sex and age between 18 and 40 years. Exclusion criteria were a current pregnancy, conspicuous tattoos, body piercings, birthmarks or port-wine stains, physical deformities, and large skin wounds. These exclusion criteria were selected in order to avoid an attention allocation toward conspicuous bodily characteristics. Moreover, certain characteristics (e.g., scars) might influence the emotional valence of body parts. In a related vein, these characteristics further reduce the similarity of body stimuli and thus threaten internal validity. The exclusion criterion of a current pregnancy was selected for ethical reasons. The study was approved by the ethics committee of the University of Osnabrück.

Assessment of Eating and Body Image Pathology

The Eating Disorder Examination-Questionnaire (EDE-Q; Fairburn and Beglin, 1994; German-language version: Hilbert et al., 2007) assesses the extent of eating disorder symptoms in the past 28 days. The self-report questionnaire consists of 27 items generating the four subscales "Restraint," "Eating concern," "Weight concern," and "Shape concern." Each item is rated on a seven-point Likert-type scale ranging from 0 (= "no days"/"not at all") to 6 (= "every day"/"markedly"). The internal consistency of the different subscales of the German-language version ranges from $\alpha = 0.85$ to $\alpha = 0.93$. The test-retest reliability lies between $r_{tt} = 0.67$ and $r_{tt} = 0.85$ (Hilbert et al., 2007).

The Body Checking Questionnaire (BCQ; Reas et al., 2002; German-language version: Vocks et al., 2008b) is a self-report questionnaire assessing the frequency of specific body-related checking behavior. It consists of 23 items, which are rated on a five-point Likert-type scale ranging from 0 (= "never") to 4 (= "very often"). For the German-language version, the internal consistency is $\alpha = 0.93$ for females with eating disorder pathology and $\alpha = 0.90$ for non-clinical females (Vocks et al., 2008b). The test-retest reliability for a sample of non-clinical females is $r_{tt} = 0.88$ (Vocks et al., 2008b).

The Body Image Avoidance Questionnaire (BIAQ; Rosen et al., 1991; German-language version: Legenbauer et al., 2007) is a self-report questionnaire consisting of 19 items which assess the frequency of body-related avoidance behavior and behavioral tendencies which are associated with body-image disturbances on the four subscales "Clothing," "Social activities," "Restraint," and "Grooming and weighing." Each item is rated on a five-point Likert-type scale ranging from 0 (= "never") to 4 (= "always"). The internal consistency of the different subscales of the German-language version ranges from $\alpha = 0.64$ to $\alpha = 0.80$. The test-retest reliability lies between $r_{tt} = 0.64$ and $r_{tt} = 0.81$ (Legenbauer et al., 2007).

The Body Image States Scale (BISS; Cash et al., 2002) is a six-item self-report questionnaire assessing state body satisfaction. The items refer to physical appearance, shape, weight, physical attractiveness, and comparison with one's usual body satisfaction as well as with an average person's appearance. Each item is answered on a nine-point Likert-type scale ranging from 0 (= "dissatisfied/unattractive") to 8 (= "satisfied/attractive"). The internal consistency ranges from $\alpha = 0.77$ to $\alpha = 0.90$, and the test-retest reliability is $r_{tt} = 0.69$ (Cash et al., 2002).

Stimulus Material

To modify the participants' attentional focus *via* the dot-probe task (MacLeod et al., 1986), pictures of the participants' positively and negatively evaluated body parts were created.

In order to create these pictures, participants initially rated 10 parts of their own body, i.e., belly, breast, buttocks, lower legs/feet, thighs, upper back, lower back, upper arms, forearms/hands, and décolleté, concerning their attractiveness, with "1" the least attractive and "10" the most attractive body part. Subsequently, for each participant, four full-body pictures were taken in front of a plain white background, with participants wearing standardized gray underwear and in four different standardized poses, i.e., front view with arms bent, back view with arms bent, front view with arms stretched upwards, and lateral view with arms stretched forwards. The full-body pictures were then cut into image sections of the 10 different body parts using an image editing program. Body part pictures had a dimension of 200 × 120 pixels. Finally, each body part picture was embedded in the dot-probe task in order to deploy them as positive and negative stimuli during the ABMT. The participants' five most attractively rated body parts were used as positive stimuli and the five least attractively rated were used as negative stimuli in the attentional training.

Attentional Bias Modification Training

In order to examine and modify the participants' attention concerning specific parts of their own body, the dot-probe task according to MacLeod et al. (1986, 2002) was conducted. This version of the task has been applied in diverse previous studies examining attentional bias and its modification in different research fields (Shafran et al., 2007; Smith and Rieger, 2009; Bar-Haim, 2010; Hakamata et al., 2010) and has led to important findings on attentional bias toward disorder-specific stimuli. We employed attentional training *via* the dot-probe task, with three different training conditions comprising a positive, negative, and control condition (MacLeod et al., 1986; Renwick et al., 2013). Participants were seated at about 60 cm viewing distance in front of a monitor. No chin rest was used. At the beginning of the dot-probe task, a fixation cross was presented in the center of the screen for 500 ms (see **Figure 1**). Subsequently, two competing pictures of a positive and a negative part of the participants' body appeared for 500 ms, with one picture presented on the upper half and one on the lower half of the screen with a distance of 3 cm. Following the presentation of the pictures, a target probe, either "*" or "**," was shown at the location of the positive or the negative picture. The location of the target probe depended on the training condition: In the positive training condition, for inducing an attentional bias toward positive parts of one's own body, the target probe appeared exclusively at the location of the positive pictures. In the negative training condition, for inducing an attentional bias toward negative parts of one's own body, the target probe appeared exclusively at the location of the negative pictures. In the control condition, the target probe appeared randomly, with equal frequency, at either location. Participants were instructed to react to the target probe as quickly and accurately as possible by pressing the "1"″ key on the keyboard for "*" and the "2"″ key for "**."

Hardware and Software

For presenting the dot-probe task, a 17″ TFT LCD Iiyama monitor with a 1,280 × 1,024 pixel definition and the E-Prime-software (version 2.0) were used. The participants' full-body pictures were taken using a Nixon Coolpix L120 automatic camera on a tripod. To generate the image sections showing the participants' body parts, the picture editing software GIMP 2 was used.

Procedure

First, participants were informed about the course of the study and written consent was obtained from each participant without disclosing the aim of the investigation at that time. As a cover story, participants were told that the study was an assessment of reaction times. Participants were informed that during the task, the pictures of their own body parts would be presented on a screen. After generating the pictures of the body parts, which served as positive and negative stimuli in the ABMT, participants completed the BISS and were asked to carry out the dot-probe task presented on a screen. First, participants underwent three test trials using pictures of furniture as neutral stimuli in order to rectify any individual problems concerning the dot-probe task. Second, the pre-training measurement was administered. In 100 trials, the target probe randomly occurred with equal frequency at the location of pictures of positive and negative parts of one's own body. Third, the ABMT was carried out. For this purpose, participants were randomly allocated to the positive, the negative, or the control condition of the dot-probe task, each comprising 500 training trials. This was followed by 100 trials of the post-training measurement, which exactly mirrored the pre-training measurement. After the ABMT, participants again completed the BISS and subsequently the self-report questionnaire battery.

Statistical Analyses

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS, Version 25.0). First, the three training groups were compared in terms of age, body mass index, and their scores on the EDE-Q, BCQ, and BIAQ using a one-way ANOVA including Levene's test of homogeneity of variances.

In order to compare the reaction times to pictures of positive and negative parts of one's own body, a paired-sample t-test was conducted.

Furthermore, in order to investigate the reaction times to pictures of positive and negative parts of one's own body before and after the ABMT, a two-way ANOVA with the within-subjects factor Time (i.e., reaction times before and after the ABMT) and the between-subjects factor Group (i.e., positive, negative, and neutral training condition) was conducted.

Additionally, in order to examine the BISS scores before and after the ABMT, a two-way ANOVA with the within-subjects factor Time (i.e., before and after the ABMT) and the between-subjects factor Group (i.e., positive, negative and neutral training condition) was conducted.

In order to examine the association between attentional bias before the ABMT and the change in the degree of body dissatisfaction from pre- to post-ABMT, product-moment correlation coefficients were computed, with respect to the positive condition and the negative condition of the ABMT. To represent the extent of attentional bias before the ABMT, we calculated a bias score by subtracting reaction times to negatively evaluated body parts from reaction times to positively evaluated body parts. To represent the change in the degree of body dissatisfaction from pre- to post-ABMT, the degree of body dissatisfaction after the ABMT was subtracted from the degree of body dissatisfaction before the ABMT.

For all analyses, the significance level was set at $p < 0.05$ (two-tailed).

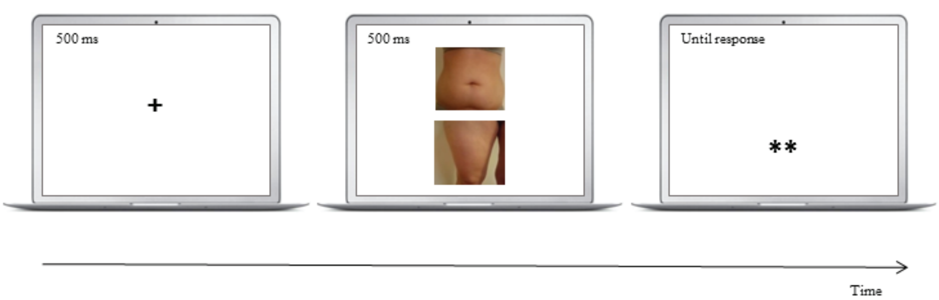

FIGURE 1 | Sequence of a dot-probe task trial showing an example of stimuli used in the dot-probe task. Note: +fixation cross; **target probe.

RESULTS

Participants' Characteristics

Participants' characteristics are presented in **Table 1**. No significant group differences between participants in the positive training condition, the negative training condition, and in the control condition were found for age, body mass index, and the questionnaire measures.

There were no differences in reaction times to positive parts of one's own body between the three groups before the ABMT was executed, $F(2, 57) = 0.07$, $p = 0.936$. Moreover, there were no differences in reaction times to negative parts of one's own body between the three groups before the ABMT was executed, $F(2, 57) = 0.04$, $p = 0.965$.

Comparison of the Reaction Times (in Milliseconds) to Pictures of Positive and Negative Parts of One's Own Body Before the Attentional Bias Modification Training

The results of a paired-sample *t*-test revealed no differences in reaction times to negative parts of one's own body compared to positive parts of one's own body in the context of the dot-probe task before the ABMT was executed, $t(59) = 1.16$, $p = 0.251$, $d = 0.04$. This finding indicates that there is no attentional bias toward negative parts of one's own body in non-clinical women.

Comparison of the Reaction Times (in Milliseconds) to Pictures of Positive and Negative Parts of One's Own Body Before and After the Attentional Bias Modification Training

Reaction times to pictures of positive parts of one's own body before and after the ABMT for the three groups are reported in **Table 2**. A significant main effect of Time was found, with a decrease in reaction times from pre- to post-training across the three groups, $F(1, 57) = 11.25$, $p = 0.001$, $\eta_p^2 = 0.17$. However, there was no significant main effect of Group, indicating no difference in reaction times in the three groups across the two time points, $F(2, 57) = 0.69$, $p = 0.507$, $\eta_p^2 = 0.02$. Furthermore, the ANOVA revealed no significant Time × Group interaction, indicating that there were no differences between the three training conditions regarding the change in reaction times from pre- to post-ABMT, $F(2, 57) = 2.18$, $p = 0.123$, $\eta_p^2 = 0.07$.

Reaction times to pictures of negative parts of one's own body before and after the ABMT for the three groups are reported in **Table 3**. Again, a significant main effect of Time was observed, with a decrease in reaction times from pre- to post-training across the three groups, $F(1, 57) = 4.96$, $p = 0.030$, $\eta_p^2 = 0.08$. There was no significant main effect of Group, indicating no difference in reaction times in the three groups across the two time points, $F(2, 57) = 0.36$, $p = 0.697$, $\eta_p^2 = 0.01$. Moreover, the Time × Group interaction did not reach statistical significance, indicating that there were no differences between the three training conditions regarding the change in reaction times from pre- to post-ABMT, $F(2, 57) = 3.01$, $p = 0.057$, $\eta_p^2 = 0.10$.

Comparison of the Degree of Body Dissatisfaction Before and After the Attentional Bias Modification Training

The degree of body dissatisfaction before and after the ABMT for the three groups is reported in **Table 4**. There was no main effect of Time, indicating no change in the degree of body dissatisfaction from pre- to post-training across the three groups, $F(1, 55) = 2.59$, $p = 0.114$, $\eta_p^2 = 0.05$. Moreover, there was no significant main effect of Group, indicating no difference in the degree of body dissatisfaction in the three groups across the two time points, $F(2, 55) = 1.13$, $p = 0.332$, $\eta_p^2 = 0.04$. Furthermore, the ANOVA revealed no significant Time × Group interaction, indicating that there were no differences between the three training conditions regarding the change in the degree of body dissatisfaction from pre- to post-ABMT, $F(2, 55) = 0.98$, $p = 0.381$, $\eta_p^2 = 0.03$.

Correlations Between Attentional Bias and Changes in Body Dissatisfaction From Pre- to Post-attentional Bias Modification Training

Attentional bias before the ABMT was not significantly correlated with the change in the degree of body dissatisfaction from pre- to post-ABMT for positively evaluated body parts ($r = -0.42$; $p = 0.071$). Moreover, no significant correlation was observable between attentional bias before the ABMT and the change in

TABLE 1 | Means (*M*) and standard deviations (SD) of participants' characteristics and questionnaire measures.

Dependent variable	Total sample		Positive condition		Negative condition		Control condition		Group comparison		
	M	SD	*M*	SD	*M*	SD	*M*	SD	*F*	df	*p*
Age	22.49	2.94	23.25	3.51	21.85	2.74	22.37	2.41	1.17	2	0.319
BMI	21.81	2.48	22.37	3.08	22.01	2.07	21.07	2.09	1.48	2	0.236
EDE-Q	1.01	0.76	0.96	0.82	1.13	0.74	0.93	0.75	0.38	2	0.684
BCQ	0.68	0.34	0.68	0.38	0.59	0.18	0.78	0.42	0.81	2	0.453
BIAQ	0.42	0.43	0.47	0.51	0.38	0.27	0.40	0.47	0.25	2	0.782

Age in years; BMI, body mass index in kg/m^2; EDE-Q, Eating Disorder Examination-Questionnaire; BCQ, Body Checking Questionnaire; BIAQ, Body Image Avoidance Questionnaire; F, F value; df, degrees of freedom; p, p value.

TABLE 2 | Means (*M*), standard deviations (SD), and effect size (*d*) of the reaction times (in milliseconds) to pictures of positive parts of one's own body before and after the ABMT.

Training condition	Pre-training		Post-training		Cohen's *d*
	M	SD	*M*	SD	*d*
Positive condition	487.12	74.77	462.08	58.71	0.33
Negative condition	489.42	102.69	483.95	114.38	0.05
Control condition	480.41	61.89	437.86	39.87	0.69

TABLE 3 | Means (*M*), standard deviations (SD), and effect size (*d*) of the reaction times (in milliseconds) to pictures of negative parts of one's own body before and after the ABMT.

Training condition	Pre-training		Post-training		Cohen's *d*
	M	SD	*M*	SD	*d*
Positive condition	485.76	74.24	463.69	61.28	0.30
Negative condition	479.28	94.53	487.37	127.23	–0.09
Control condition	482.41	55.74	444.10	40.58	0.69

TABLE 4 | Means (*M*), standard deviations (SD), and effect size (*d*) of the degree of body dissatisfaction before and after the ABMT.

Training condition	Pre-training		Post-training		Cohen's *d*
	M	SD	*M*	SD	*d*
Positive condition	5.26	1.44	5.30	1.41	–0.02
Negative condition	4.90	1.17	4.47	1.47	0.37
Control condition	5.14	1.17	4.87	1.41	0.23

the degree of body dissatisfaction from pre- to post-ABMT for negatively evaluated body parts ($r = -0.21$; $p = 0.369$).

DISCUSSION

The aim of the present study was to test, using a dot-probe task, whether women display an attentional bias toward negatively valenced parts of their own body and whether this attentional bias as well as body dissatisfaction can be modified by ABMT. To our knowledge, this is the first study to use this approach by presenting pictures of the participants' own body parts in order to examine and modify an attentional bias.

Contrary to our hypothesis, no difference emerged in participants' reaction times toward negatively and positively valenced body parts, suggesting no attentional bias toward self-defined unattractive parts of one's own body. This finding is consistent with the results of the eye-tracking study by Tuschen-Caffier et al. (2015), in which non-clinical women displayed a balanced attentional focus on positively and negatively valenced parts of their own body. Furthermore, these results indicating balanced attention regarding one's own body support the assumption of the integrated cognitive-behavioral model of eating disorders (Williamson et al., 2004) that attentional biases are linked to a negative body-related self-schema. As the participants in our study displayed a generally low level of eating disorder symptoms, it might be assumed that they had a less pronounced negative body-related self-schema, thus providing an explanation for the finding that they did not show biased attention. This consideration is supported by various studies using the dot-probe task (Rieger et al., 1998; Smith and Rieger, 2009; Blechert et al., 2010; Gao et al., 2011) or an eye-tracking approach (Roefs et al., 2008; Tuschen-Caffier et al., 2015; Bauer et al., 2017), which found that the extent of attentional bias toward negative stimuli is linked to the degree of body dissatisfaction.

Moreover, our hypothesis that an attentional bias as well as the degree of body dissatisfaction can be modified by ABMT based on a dot-probe task comprising pictures of the participants' own body parts could not be confirmed. Instead, the study demonstrated that there were no changes either in reaction times to pictures of the participants' body parts or in the degree of body dissatisfaction from pre- to post-ABMT in the three groups, indicating that there were no intervention effects. Furthermore, there was no correlation between the extent of attentional bias before the ABMT and the magnitude of change in the degree of body dissatisfaction from pre- to post-ABMT, indicating that the ABMT did not work better for participants who showed a higher extent of biased attention. In this respect, our findings are partially in accordance with the results of Smeets et al. (2011a), who also did not find an effect of the ABMT toward positively evaluated body areas, as indicated by a lack of change in body satisfaction. However, the latter authors did detect an effect of the ABMT toward negatively valenced body parts, as body satisfaction decreased after the ABMT, a finding which could not be confirmed in our study.

In this regard, the lack of effect of the ABMT toward the positively evaluated body parts might be due to the fact that the participants in our study showed a generally low level of shape and weight concerns (for reference values, see Hilbert and Tuschen-Caffier, 2016), leading to the assumption that there was little scope for improving attentional focus and for enhancing body satisfaction after the ABMT toward positively valenced body parts. This is in accordance with the assumption of the integrated cognitive-behavioral model of eating disorders (Williamson et al., 2004) that women with eating disorder symptoms display more distinctive attentional biases than women without eating disorder symptoms, with a consequently higher scope for improvement after ABMT. In this vein, results from anxiety disorder research indicate that the impact of ABMT might depend on symptom severity. For instance, in a meta-analysis, Hakamata et al. (2010) found that the effects of ABMT on anxiety symptoms are greater in clinical than in non-clinical samples. Likewise, eating disorder research has shown that the higher the degree of eating disorder and body image disturbance symptoms, the more pronounced the changeability of body image-related measures (Tuschen-Caffier et al., 2003; Vocks et al., 2009; Kraus et al., 2015). This might explain the lack of effect of the ABMT in our study, as our participants did not show clinical symptoms.

Moreover, the different results concerning the effect of the negative condition of the ABMT in our study might lie in the fact that, in contrast to Smeets et al. (2011a), who only used the three most attractive and unattractive body parts out of a total of 12 ranked body parts, we did not exclude body pictures rated in the medium range of attractiveness. This might have led to only small differences in the emotional valences of the pictures presented in the training, which did not provide a sufficient contrast to create a disparity between the training conditions.

Additionally, in contrast to the present study, participants in the study by Smeets et al. (2011a) showed a moderate degree of body dissatisfaction. As mentioned above, a higher degree of eating disorder and body image disturbance symptoms seems to be linked to a more pronounced changeability of body image-related measures (Tuschen-Caffier et al., 2003; Vocks et al., 2009; Kraus et al., 2015) and a more distinct attentional bias, with a higher scope for change in attentional bias and body dissatisfaction after ABMT (Williamson et al., 2004). In this respect, as a heightened symptom level might be linked to an increased vulnerability, it might be assumed that the participants' heightened level of body dissatisfaction in the study by Smeets et al. (2011a) was associated with the effect of the ABMT towards negatively evaluated body parts, as indicated by a decrease in body satisfaction after the ABMT. Nevertheless, although participants showed a moderate degree of body dissatisfaction, the initial ABMT towards positively evaluated body parts did not lead to an increase in the degree of body satisfaction.

Furthermore, it should be taken into account that we conducted a single session of ABMT comprising 500 trials. As previous studies indicated that a single session delivers smaller effects compared to multisession training (Field et al., 2009; Hakamata et al., 2010; Schmitz and Svaldi, 2017), it is possible that repetitive training sessions of a longer duration and comprising a higher number of trials might have led to a change in the attentional focus and in body satisfaction.

However, as the participants in our study showed a low level of shape and weight concerns, with presumably little scope for improving attentional focus and for increasing body satisfaction after the ABMT toward positively valenced body parts, it might be assumed that multisession training would not have changed the corresponding results. There may, though, have been sufficient scope for a decrease in body satisfaction after the ABMT towards negatively valenced body parts. As we were investigating a novel ABMT approach, we aimed to examine the effects of the ABMT towards both positively and negatively evaluated body parts.

Additionally, previous studies revealed that ABMT yields greater effects when words rather than pictures are used as target stimuli in a dot-probe task (for a review, see Smith and Rieger, 2009; Hakamata et al., 2010; Renwick et al., 2013). Therefore, it cannot be ruled out that the inclusion of pictures of body parts as target stimuli might have attenuated the effects of the ABMT. Moreover, the sample size was small, leading to insufficient statistical power to detect possibly existing small group differences. Hence, replications of this study with a larger sample size are warranted. Beyond these considerations concerning sample size, further studies should focus on examining a clinical or sub-clinical sample, as it might be expected that a heightened level of shape and weight concerns provides more scope for improving attentional focus and increasing body satisfaction (Williamson et al., 2004). Due to ethical considerations, a clinical sample should merely undergo the positive and the neutral condition of the ABMT. As the negative condition of the ABMT aimed to induce an attentional focus on negatively evaluated parts of one's own body as well as a decrease in body satisfaction, for ethical reasons, we chose a non-clinical sample to examine this novel ABMT approach in order to inform future applications in participants with eating disorder symptoms.

Finally, it should be taken into account that within the ABMT based on the dot-probe task employed in our study, the body parts were presented discretely and were therefore not integrated into a representation of the participants' entire body. This fragmented representation of the body might have led to a limited ecological validity, and thus to a decreased transferability of the ABMT to the participants' attentional focus in daily life as well as to body satisfaction. In this respect, as body exposure comprises the presentation of the entire body as well as its movements during mirror exposure sessions, this method for directing the attentional focus towards positively valenced body areas might lead to higher ecological validity (Vocks et al., 2007, 2008a; Griffen et al., 2018).

Overall, the results provide hints that the ABMT based on a dot-probe task, comprising pictures of the participants' own body parts, is not a promising approach for modifying the attentional focus and the degree of body dissatisfaction. In our study in a non-clinical sample, the degree of body satisfaction was neither increased nor decreased by means of the ABMT. As such, the results suggest that this approach is not suitable for modifying attention allocation and the degree of body satisfaction. This is also in accordance with findings from anxiety disorder research, as Carlbring et al. (2012) did not succeed in modifying attentional bias in participants with social anxiety symptoms. The present study contributes to the current debate concerning the reliability of the dot-probe task as a measure of attentional bias as well as concerning the utility of ABMT based on a dot-probe task (Clarke et al., 2014). Results of previous studies examining attentional bias towards threat-related stimuli suggested that the dot-probe task shows only limited reliability for measuring attentional bias (Schmukle, 2005; Kruijt et al., 2019). To increase the reliability of a dot-probe task-based measurement, previous studies suggested that a larger sample size as well as a comparison of clinical and non-clinical samples are required (Schmukle, 2005; Kruijt et al., 2019). Although the study by Schmukle (2005) found that the dot-probe task comprising threat-related stimuli was an unreliable measure of the attentional focus in non-clinical participants, there are no hints that these results are applicable to the field of eating disorder research and to studies on the attentional focus on body-related stimuli. Furthermore, Schmukle (2005) emphasized that the findings of low reliability of the dot-probe task are not applicable to experimental treatments aiming to induce an attentional bias.

Therefore, it appeared reasonable to examine and modify the attentional focus on parts of one's own body in a non-clinical sample using the dot-probe paradigm. Beyond these considerations concerning the measurement of biased attention by means of a dot-probe task, nowadays, more reliable and adjuvant methods for measuring attentional bias are available. In this respect, as various eye-tracking studies have provided important results concerning attention allocation in clinical and non-clinical participants (Jansen et al., 2005; Roefs et al., 2008; Tuschen-Caffier et al., 2015; Bauer et al., 2017), it might be assumed that the assessment of participants' eye movements using an eye-tracker constitutes a suitable approach for measuring the attentional focus on one's own body.

In conclusion, previous research indicates that body-related biased attention seems to contribute to the etiology and maintenance of body dissatisfaction, which is postulated to constitute a risk factor in the development of eating disorders. However, as eating disorder symptoms appear to persist despite psychotherapeutic treatments, it is of particular importance to generate effective interventional methods addressing body-related attentional biases. In this regard, further examinations are needed and should take the considerations and conclusions of this study into account.

DATA AVAILABILITY STATEMENT

The datasets for this manuscript are not publicly available because the local ethics committee of Osnabrück University stipulated that data must not be passed on to third parties. Request to access the datasets should be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics committee of the Osnabrück University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SV, MW, and AV-E planned and conducted the study. AV-E programmed the experimental procedure and was involved in the development of the stimuli manipulation procedure. NE, SV, MW, and AH analyzed the data. NE wrote the first draft of the manuscript. All authors contributed to the compilation of the manuscript and read and approved the submitted version.

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REFERENCES

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders. 5th Edn*. Washington, DC: American Psychiatric Association.

Aspen, V., Darcy, A., and Lock, J. (2013). A review of attention biases in women with eating disorders. *Cognit. Emot.* 27, 820–838. doi: 10.1080/02699931.2012.749777

Bar-Haim, Y. (2010). Research review: attention bias modification (ABM): a novel treatment for anxiety disorders. *J. Child Psychol. Psychiatry* 51, 859–870. doi: 10.1111/j.1469-7610.2010.02251.x

Bauer, A., Schneider, S., Waldorf, M., Braks, K., Huber, T. J., Adolph, D., et al. (2017). Selective visual attention towards oneself and associated state body dissatisfaction: an eye-tracking study in adolescents with different types of eating disorders. *J. Abnorm. Child Psychol.* 45, 1647–1661. doi: 10.1007/s10802-017-0263-z

Blechert, J., Ansorge, U., and Tuschen-Caffier, B. (2010). A body-related dot-probe task reveals distinct attentional patterns for bulimia nervosa and anorexia nervosa. *J. Abnorm. Psychol.* 119, 575–585. doi: 10.1037/a0019531

Carlbring, P., Apelstrand, M., Sehlin, H., Amir, N., Rousseau, A., Hofmann, S. G., et al. (2012). Internet-delivered attention bias modification training in individuals with social anxiety disorder - a double blind randomized controlled trial. *BMC Psychiatry* 12:66. doi: 10.1186/1471-244X-12-66

Cash, T. F. (2011). "Cognitive-behavioural perspectives on body image" in *Body image: A handbook of science, practice, and prevention*. eds. T. F. Cash and L. Smolak (New York: Guilford), 39–47.

Cash, T. F., Fleming, E. C., Alindogan, J., Steadman, L., and Whitehead, A. (2002). Beyond body image as a trait: the development and validation of the body image state scale. *Eat. Disord.* 10, 103–113. doi: 10.1080/10640260290081678

Clarke, P. J., Notebaert, L., and MacLeod, C. (2014). Absence of evidence or evidence of absence: reflecting on therapeutic implementations of attentional bias modification. *BMC Psychiatry* 14:8. doi: 10.1186/1471-244X-14-8

Fairburn, C. G., and Beglin, S. J. (1994). Assessment of eating disorders: interview or self-report questionnaire? *Int. J. Eat. Disord.* 16, 363–370.

Field, M., Munafo, M. R., and Franken, I. H. (2009). A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychol. Bull.* 135, 589–607. doi: 10.1037/a0015843

Gao, X., Wang, Q., Jackson, T., Zhao, G., Liang, Y., and Chen, H. (2011). Biases in orienting a and maintenance of attention among weight dissatisfied women: an eye-movement study. *Behav. Res. Ther.* 49, 252–259. doi: 10.1016/j.brat.2011.01.009

Griffen, T. C., Naumann, E., and Hildebrandt, T. (2018). Mirror exposure therapy for body image disturbances and eating disorders: a review. *Clin. Psychol. Rev.* 65, 163–174. doi: 10.1016/j.cpr.2018.08.006

Hakamata, Y., Lissek, S., Bar-Haim, Y., Britton, J. C., Fox, N., Leibenluft, E., et al. (2010). Attention bias modification treatment: a meta-analysis towards the establishment of novel treatment for anxiety. *Biol. Psychiatry* 68, 982–990. doi: 10.1016/j.biopsych.2010.07.021

Hilbert, A., and Tuschen-Caffier, B. (2016). *Eating disorder examination-questionnaire, Deutschsprachige Übersetzung*. Tübingen: DGVT Verlag.

Hilbert, A., Tuschen-Caffier, B., Karwautz, A., Niederhofer, H., and Munsch, S. (2007). Eating disorder examination-questionnaire. Evaluation der deutschsprachigen Übersetzung. *Diagnostica* 53, 144–154. doi: 10.1026/0012-1924.53.3.144

Hrabosky, J. I., Cash, T. F., Veale, D., Neziroglu, F., Soll, E. A., Garner, D. M., et al. (2009). Multidimensional body image comparisons among patients with eating disorders, body dysmorphic disorder, and clinical controls: a multisite study. *Body Image* 6, 155–163. doi: 10.1016/j.bodyim.2009.03.001

Jansen, A., Nederkoorn, C., and Mulkens, S. (2005). Selective visual attention for ugly and beautiful body parts in eating disorders. *Behav. Res. Ther.* 43, 183–196. doi: 10.1016/j.brat.2004.01.003

Kearney-Cooke, A., and Tieger, D. (2015). "Body image disturbance and the development of eating disorders" in *The Wiley handbook of eating disorders*. eds. L. Smolak and M. P. Levine (Chichester: Wiley Blackwell), 283–296.

Kerr-Gaffney, J., Harrison, A., and Tchanturia, K. (2019). Eye-tracking research in eating disorders: a systematic review. *Int. J. Eat. Disord.* 52, 3–27. doi: 10.1002/eat.22998

Kraus, N., Lindenberg, J., Zeeck, A., Kosfelder, J., and Vocks, S. (2015). Immediate effects of body checking behaviour on negative and positive emotions in females with eating disorders: an ecological momentary assessment approach. *Eur. Eat. Disord. Rev.* 23, 399–407. doi: 10.1002/erv.2380

Kruijt, A. W., Parsons, S., and Fox, E. (2019). A meta-analysis of bias at baseline in RCTs of attention bias modification: no evidence for dot-probe bias towards threat in clinical anxiety and PTSD. *J. Abnorm. Psychol.* 128, 563–573. doi: 10.1037/abn0000406

Lee, M., and Shafran, R. (2004). Information processing biases in eating disorders. *Clin. Psychol. Rev.* 24, 215–238. doi: 10.1016/j.cpr.2003.10.004

Legenbauer, T., Vocks, S., and Schütt-Strömel, S. (2007). Validierung einer deutschsprachigen version des body image avoidance questionnaire BIAQ. *Diagnostica* 53, 218–225. doi: 10.1026/0012-1924.53.4.218

MacLeod, C. (2012). Cognitive bias modification procedures in the management of mental disorders. *Curr. Opin. Psychiatry* 25, 114–120. doi: 10.1097/YCO.0b013e32834fda4a

MacLeod, C., Mathews, A., and Tata, P. (1986). Attentional bias in emotional disorders. *J. Abnorm. Psychol.* 95, 15–20. doi: 10.1037/0021-843X.95.1.15

MacLeod, C., Rutherford, E., Campbell, L., Ebsworthy, G., and Holker, L. (2002). Selective attention and emotional vulnerability: assessing the causal basis of their association through the experimental manipulation of attentional bias. *J. Abnorm. Psychol.* 111, 107–123. doi: 10.1037/0021-843X.111.1.107

Reas, D. L., Whisenhunt, B. L., Netemeyer, R., and Williamson, D. A. (2002). Development of the body checking questionnaire: a self-report measure of body checking behaviours. *Int. J. Eat. Disord.* 31, 324–333. doi: 10.1002/eat.10012

Renwick, B., Campbell, I. C., and Schmidt, U. (2013). Review of attentional bias modification: a brain-directed treatment for eating disorders. *Eur. Eat. Disord. Rev.* 21, 464–474. doi: 10.1002/erv.2248

Rieger, E., Schotte, D. E., Touyz, S. W., Beumont, P. J. V., Griffiths, R., and Russell, J. (1998). Attentional biases in eating disorders: a visual probe detection procedure. *Eat. Disord.* 23, 199–205. doi: 10.1002/(SICI)1098-108X(199803)23:2<199::AID-EAT10>3.0.CO;2-W

Roefs, A., Jansen, A., Moresi, S., Willems, P., Van Grootel, S., and Van der Borgh, A. (2008). Looking good. BMI, attractiveness bias and visual attention. *Appetite* 51, 552–555. doi: 10.1016/j.appet.2008.04.008

Rosen, J. C., Srebnik, D., Saltzberg, E., and Wendt, S. (1991). Development of a body image avoidance questionnaire. *J. Consult. Clin. Psychol.* 3, 32–37. doi: 10.1037/1040-3590.3.1.32

Schmitz, F., and Svaldi, J. (2017). Effects of bias modification training in binge eating disorder. *Behav. Ther.* 48, 707–717. doi: 10.1016/j.beth.2017.04.003

Schmukle, S. C. (2005). Unreliability of the dot probe task. *Eur. J. Personal.* 19, 595–605. doi: 10.1002/per.554

Schuck, K., Munsch, S., and Schneider, S. (2018). Body image perceptions and symptoms of disturbed eating behavior among children and adolescents in Germany. *Child Adolesc. Psychiatry Ment. Health* 12:1. doi: 10.1186/s13034-018-0216-5

Shafran, R., Lee, M., Cooper, Z., Palmer, R. L., and Fairburn, C. G. (2007). Attentional bias in eating disorders. *Int. J. Eat. Disord.* 40, 369–380. doi: 10.1002/eat.20375

Smeets, E., Jansen, A., and Roefs, A. (2011a). Bias for the (un)attractive self: on the role of attention in causing body (dis)satisfaction. *Health Psychol.* 30, 360–367. doi: 10.1037/a0022095

Smeets, E., Tiggemann, M., Kemps, E., Mills, J. S., Hollitt, S., Roefs, A., et al. (2011b). Body checking induces an attentional bias for body-related cues. *Int. J. Eat. Disord.* 44, 50–57. doi: 10.1002/eat.20776

Smith, E., and Rieger, E. (2006). The effect of attentional bias toward shape- and weight-related information on body dissatisfaction. *Int. J. Eat. Disord.* 39, 509–515. doi: 10.1002/eat.20291

Smith, E., and Rieger, E. (2009). The effect of attentional training on body dissatisfaction and dietary restriction. *Eur. Eat. Disord. Rev.* 17, 169–176. doi: 10.1002/erv.921

Stice, E., Marti, N., and Durant, S. (2011). Risk factors for onset of eating disorders: evidence of multiple risk pathways from an 8-year prospective study. *Behav. Res. Ther.* 49, 622–627. doi: 10.1016/j.brat.2011.06.009

Tuschen-Caffier, B., Bender, C., Caffier, D., Klenner, K., Braks, K., and Svaldi, J. (2015). Selective visual attention during mirror exposure in anorexia and bulimia nervosa. *PLoS One* 10:12. doi: 10.1371/journal.pone.0145886

Tuschen-Caffier, B., Vögele, C., Bracht, S., and Hilbert, A. (2003). Psychological responses to body shape exposure in patients with bulimia nervosa. *Behav. Res. Ther.* 41, 573–586. doi: 10.1016/S0005-7967(02)00030-X

Vocks, S., Hechler, T., Rohrig, S., and Legenbauer, T. (2009). Effects of a physical exercise session on state body image. The influence of pre-experimental body dissatisfaction and concerns about weight and shape. *Psychol. Health* 24, 713–728. doi: 10.1080/08870440801998988

Vocks, S., Kosfelder, J., Wucherer, M., and Wächter, A. (2008a). Does habitual body avoidance and checking behaviour influence the decrease of negative emotions during body exposure in eating disorders? *Psychother. Res.* 18, 412–419. doi: 10.1080/10503300701797008

Vocks, S., Legenbauer, T., Wächter, A., Wucherer, M., and Kosfelder, J. (2007). What happens in the course of body exposure? Physiological, cognitive and affective reactions to mirror confrontation in eating disorders. *J. Psychosom. Res.* 62, 231–239. doi: 10.1016/j.jpsychores.2006.08.007

Vocks, S., Moswald, C., and Legenbauer, T. (2008b). Psychometrische überprüfung einer deutschsprachigen fassung des body checking questionnaire (BCQ). *Z. Kl. Psych. Psychoth.* 37, 131–140. doi: 10.1026/1616-3443.37.2.131

Werthmann, J., Field, M., Roefs, A., Nederkoorn, C., and Jansen, A. (2014). Attention bias for chocolate increases chocolate consumption: an attention bias modification study. *J. Behav. Ther. Exp. Psychiatry* 45, 136–143. doi: 10.1016/j.jbtep.2013.09.009

Westerberg-Jacobson, J., Edlund, B., and Ghaderi, A. (2010). A 5-year longitudinal study of the relationship between the wish to be thinner, lifestyle behaviours and disturbed eating in 9–20-year old girls. *Eur. Eat. Disord. Rev.* 18, 207–219. doi: 10.1002/erv.983

Williamson, D. A., White, M. A., York-Crowe, E., and Stewart, T. M. (2004). Cognitive-behavioural theories of eating disorders. *Behav. Modif.* 28, 711–738. doi: 10.1177/0145445503259853

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Body Size Judgments at 17 ms: Evidence From Perceptual and Attitudinal Body Image Indexes

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Evidence related to temporal control for stimuli presentation of whole-body image is generally associated with attentional bias to ideal thin bodies. Few studies present evidence concerning whole-body stimuli recognition during fast visual exposure intervals. The aim of this study was to evaluate the accuracy and reaction times for the judgment of different sized body silhouettes presented at 17 ms in a non-clinical sample. Thirty-one participants were divided in attitudinal and perceptual body image groups based on Figure Rating Scale output and performed two experiments. First experiment assessed perception and the clarity of visual experience for human and non-human body stimuli at 17 ms. A general accuracy of 69.17% was registered with no differences between perceptual and attitudinal body image groups. These results indicated that the way participants perceive their own bodies does not influence the recognition of general visual silhouette stimuli. It was also observed that the clarity of visual experience is positively correlated to stimuli recognition accuracy. In the second experiment participants had to respond in a seven-point Likert scale if the presented image of body silhouettes were bigger, equal or thinner than their own bodies. Trials were divided in two blocks based on spatial rotation, half at 0° and half at 180°. General accuracy for body silhouettes recognition was 41.1%. Greater accuracy recognition for regular positioned stimuli was observed. Attitudinal dimension of body image was not a predictor of differential performance whereas perceptual body image groups recorded contrasting recognition performance. Distorted body image participants presented higher accuracy than undistorted body image participants, with greater accuracy to thinner silhouette figures. Women had significantly higher overall accuracy than men considering both experimental blocks. When comparing the cumulative accuracy curves across experimental trials, an exposure effect was registered only for the first experiment. Results showed that body silhouette stimuli were judged in a fast exposure interval with differential accuracy rates only for perceptual body image groups. Such evidence signals that conscious body image can be associated to implicit detection of visual human body stimuli. Future studies should further test how traditional explicit body image outputs perform within experimental approaches.

Keywords: body image, implicit cognition, perceptual awareness, experimental psychology, size judgment

Abbreviations: BMI, body mass index; BSQ, body shape questionnaire; FRS, figure rating scale; PAS, perceptual awareness scale.

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INTRODUCTION

Body image has been systematically investigated through a set of experimental methods that include evaluation of size judgment and perceptual awareness paradigms. Research on the topic has its modern roots in the beginning of the twentieth century (DeVignemont and Alsmith, 2017). However, the emergence of systematic research is tied to the use of depictive methods such as silhouettes scales (Stunkard et al., 1983) or self-report scales assessing an attitudinal dimension of body image (Menzel et al., 2011). By attitudinal dimension, literature in the field generally refers to feelings of satisfaction or dissatisfaction a person has about their body size and shape (Cornelissen et al., 2019). Even though these evaluation strategies specify patterns of experience toward its own body, little was known of perceptual body image until experimental methods were applied to the investigation (Martel et al., 2016). Conceptually, perceptual body image is usually associated with the accuracy with which a person can judge their own body size dimensions (Mölbert et al., 2017). Research on body recalibration and proprioception (e.g., Rubber Hand Illusion – Botvinick and Cohen, 1998) helped to shape investigations on perceptual body image dimension. At the same time, evidence from the somatosensory cortex associated to body image perception (Longo and Haggard, 2010) made clear that perception of the body is not a binary process, in the sense that an individual has or not a body image conscious experience in a specific moment. Instead, old definitions of body image that supposed a continuous process of body perception throughout action control and sense of position in space were summoned (e.g., Schilder, 1999). Contemporary integrative models assuming a continuous process between implicit cognition to explicit self-referred perception of its own body have taken mainstream discussion on body image (e.g., Pitron et al., 2018). Such models can be traced back to inputs from Maurice Merleau-Ponty's phenomenology (Merleau-Ponty, 2006), but have been revived in recent cognitive science by representational models of low- and high-level cognition (e.g., Longo and Haggard, 2012; Cardinali et al., 2016).

Research on body image has intensified over the past three decades driven by clinical studies that have identified body image distortion and dissatisfaction in different population. Such growth has been accompanied by innumerous instruments willing to assess body image (Kling et al., 2019). However, most of the available tools are based on a reflective concept, which targets a thematic body image consciousness. As pointed out in the scientific beginning of the field, body image comprises an extended process that is developed since the early age implying both an implicit body schema and an explicit body representation (Gallagher, 1986). Therefore, investigation should aim levels of consciousness other than explicit body image.

Even with the inclusion of experimental methods in body image research, the accessed dimension of perception is generally associated with the explicit consciousness of bodily stimuli under manipulation. In this respect, without controlling for temporal exposure of body stimuli, research in the field has difficulties to specify if what are under evaluation in perceptual body image indexes is the physiognomic recognition of stimuli or the pure size dimension judgments of the body. The emphasis on explicit aspects of body image may be highlighted by a specific methodological choice directed to assess conscious body stimuli on visual research (e.g., Barra et al., 2017; Leehr et al., 2018). This literature is more commonly associated with the presentation of face stimuli in the field of face perception aiming at the discrimination of emotions (Thompson and Wilson, 2012; D'Amour and Harris, 2017). Examples of research comprise Stoddard et al. (2017) research on the recognition of emotions and early signs of psychopathology, and Bedford et al. (2017) study on the typical development of emotion recognition in infants. On the other hand, literature associated to bodily silhouettes stimuli is traditionally linked to tasks of body appreciation without any temporal control. Few software manipulating body silhouettes applies psychophysical methods (e.g., Gardner and Boice, 2004) and seek to expand depictive research rigor. However, exposure to stimuli in software generally does not include temporal control for fast responses (Caspi et al., 2017). In this sense, without knowing or properly investigating timeframes associated to body size judgments, no assumption regarding continuity from implicit to explicit cognition can be well established.

Different research using body stimuli tend to vary visual exposure time according to specific aims of the investigation (Sekunova and Barton, 2008; Bonemei et al., 2018). However, a small number of studies have actually investigated fast presentation intervals for this kind of stimulus. Majority of studies applying temporal control are more focused in exploring responses to the size and spatial orientation of the presented body stimuli than to the effect that the applied time control for stimuli presentation has in the actual responses (Ferrer-García and Gutiérrez-Maldonado, 2008). There is little evidence to indicate the relationship between the perception of whole-body stimuli and the exposure intervals related to the processing of a specific stimulus selected by participants. Such disregard for temporal control may be explained by how part of body size estimation research theoretically refers to perception, as a process guided by semantic affective and cognitive toward the body (Smeets and Panhuysen, 1995). In this sense, evaluations aiming exclusively at explicit cognition.

Notwithstanding, evidence exists for experimental time control based research in clinical settings. For example, Rivolta et al. (2017) presented stimuli of body silhouette and neutral stimuli for 200 ms to a clinical group with difficulties on facial recognition expressions (prosopagnosia). Results showed that in addition to impairment of facial recognition, this sample also presented impairment in the recognition of faceless body silhouette stimuli. Similarly, Duncum et al. (2016) presented body stimuli, objects and scenes for 500 ms to a group of body image concern participants. The set of stimuli were randomly presented in regular and inverted orientation. Accuracy rates were higher in all conditions for the participants with lower rates of concern with body image. In relation to reaction times (RTs), participants who were more concerned with body image had a lower average RT for faces, bodies and objects when they were presented in inverted orientation. These studies exemplify the literature emphasis on time control for object recognition rather than the time limits for size judgments or to how explicit body image judgments are related to implicit recognition of the body.

There are studies demonstrating an association between dissatisfaction with body image and attention bias to idealized thin bodies (e.g., Joseph et al., 2016; Moussally et al., 2016), which could reveal a connection between explicit and implicit body image processing. However, these studies are only able to evidence bias differences between satisfied and dissatisfied groups from intervals around 500 ms above. In general, women who are more dissatisfied with their bodies have an attention bias toward idealized bodies in intervals around 500 ms. This decision making occurs in a time interval already associated with explicit processing of response selection. Little is known regarding satisfaction and dissatisfaction with body image from performance within tasks aiming initial processing of visual stimuli.

To initiate a debate over initial processing of bodily visual stimuli, beyond time control, visual detection *per se* must consider the degree of complexity of the presented stimuli. Complex stimuli tend to present more realistic and detailed feature patterns. Simple stimuli, in turn, present fewer variable properties, usually limited to two-dimension presentation (Lamberts et al., 2002; Palumbo et al., 2014). In terms of clarity of the visual experience, Sandberg et al. (2010) tested 12 intervals, from 16 to 192 ms, with gradual variations of 16 ms to understand when conscious experience starts to occur for simple stimuli. The stimuli presented by the authors were four geometric silhouette forms, later masked by the union of all silhouettes until the emission of the response. Results evidenced that in 16 ms the sample already had an almost clear experience of visualization for the whole set of stimuli, reaching clear experience from 96 ms.

For body stimuli, factors such as real images, the presence of multiple colors, the size of the image, the contrast ratio between the image and the background are aspects that increase its complexity. In such cases, the use of very brief time intervals may frustrate the aim to capture an individual's ability to discriminate such stimuli. In this sense, body stimuli could be represented reducing visual feature variability by means of pictographing the stimulus in monochromatic tones, broadening the contrast between stimulus and background, and reducing the depth of the target stimulus. In these situations, a brief temporal control of visual exposure could be successful in discriminating implicit processing of bodily stimuli. For top-down theories, as instance, pattern recognition could be applied as an explanation of how explicit body image perception is related to implicit self-representation of the body. Evidence for temporal control in the presentation of body silhouettes stimuli is not sound in body image research. In this sense no conclusive remark, considering the set of evidence available, can be established for a minimum interval necessary for its recognition in clinical and non-clinical groups.

Considering the assumption of a continuous process between implicit and explicit body image perception (Pitron et al., 2018), the aim of the present study was to evaluate body size judgments in a non-clinical sample at a brief visual exposure interval (17 ms). Two experiments were proposed to first assess the participants ability to correctly discriminate body silhouette stimuli at 17 ms (Experiment 1) and secondly to assess the participants ability to judge body size silhouettes relative to their own body size dimensions at the same timeframe (Experiment 2). The first experiment was thought as a baseline assessment for stimuli detection and an evaluation of visual clarity experience level toward body stimuli. Based on previous results (Pessoa et al., 2005), we expected participants to correctly discriminate body stimuli without a strong visual clarity experience. The main focus, however, is if non-clinical subjects will be able to produce accurate body size judgments at 17 ms in comparison to their own body size. Our hypothesis for the second experiment is that body size judgment will be accurate only when the judged stimulus represents similar size dimensions as that of the participants own body. To explore the relation between explicit and implicit cognition the sample was divided in body image groups, based on an explicit body image scale, to analyze accuracy and RT data in relation to these group divisions. Our hypothesis is that explicit criteria for body image perception will predict differential accuracy rates in the second experiment with body image distorted participants presenting lower accuracy rates than the undistorted body image participants group.

MATERIALS AND METHODS

Participants

Initially 37 participants were recruited in four local University campuses. Six participants were excluded from final analysis due to data loss or as a result of presenting clinical symptoms that could interfere in visual perception. Final sample consisted of 31 participants (19 women, mean age of 22.9 years, SD = 2.98). Participants Body mass index (BMI) average was 23.9 kg/m^2 (SD = 4.06 kg/m^2). Sample size is compatible with previous studies on visual perception in body image (e.g., Castellini et al., 2013; Forghieri et al., 2016; Bailey et al., 2017). All participants had normal or corrected-to-normal vision. The research protocol followed the ethical standards of Brazilian regulation for studies with human participants (Resolution 510/2016 of the National Health Council) and was approved by the University's Ethical Committee (Registered Protocol Number: CAAE 87592718.3.0000.5334).

Instruments

The following instruments were applied: Figure Rating Scale (FRS – Kakeshita et al., 2009), Body Shape Questionnaire (BSQ – Di Pietro and Silveira, 2009), DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure – Adult (American Psychiatry Association [APA], 2013), and a socio-demographic questionnaire.

Figure Rating Scale

The Figure Rating Scale (FRS – Kakeshita et al., 2009) applied in this study is the Brazilian adaptation and validation of Stunkard's FRS (Stunkard et al., 1983). The original instrument consisted of 18 silhouettes, nine for female participants and nine for male participants. The Brazilian version of FRS consists of 30 silhouettes, 15 silhouettes for female participants and 15 silhouettes for male participants. Each silhouette figure corresponds to an index of BMI variation. The difference between two sequential silhouettes corresponds to intervals greater than 2.5 kg/m^2 variance between each silhouette. The BMI range for the 15-silhouette set representing each gender group begins at 11.5 kg/m^2 and ends at 48.75 kg/m^2. The Brazilian FRS expanded the BMI differences between the silhouette figures, considering the diverse body patterns of the Brazilian population. Instrument application consists of asking the participant (1) which silhouette figure best represents their current body and (2) which silhouette figure best represents the body they would like to have. The Brazilian FRS provides two scores: the perceptual body image index and the attitudinal body image index. Perceptual body image index is calculated by subtracting the silhouette chosen as the participants' current body from the silhouette figure correspondent to their own measured real BMI. Attitudinal body image index is calculated by subtracting the silhouette figure chosen as the body participants' would like to have from the silhouette figure indicated as their current body. The Brazilian version of FRS presented good reliability indexes regarding the perceived body (α = 0.92) and the ideal body (α = 0.86) judgments (Griep et al., 2012). In the present study participants had a perceptual body image index average of 1.4 (SD = 1.4) variation and 0.9 (SD = 1.5) average variation for the attitudinal body image index.

Body Shape Questionnaire

The BSQ is a self-reported questionnaire that inquiries about body image general dissatisfaction. The Brazilian version of BSQ consists of 34 items corresponding four different factors: (1) self-perception of body shape, (2) comparative perception of body image, (3) attitude concerning body image alteration, and (4) severe alterations in body perception. The score sum indicates the corporal dissatisfaction in four levels: (a) no concern, (b) mild, (c) moderate, and (d) severe (Cooper et al., 1987). Validity evidence of BSQ to Brazilian population shows good internal consistency (α = 0.97) and factorial structure similar to the original questionnaire (Di Pietro and Silveira, 2009). In the present study participants presented a BSQ average of 76.8 points (SD = 25.5), which is below the cut-off point of 110 points considered for body dissatisfaction in the Brazilian version of BSQ.

DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure – Adult

The DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure – Adult consists of a mental health questionnaire for adult population. 23 screening items evaluate the following psychiatric domains: anxiety, depression, dissociation, sleep disorder, personality functioning, suicidal ideation, mania, memory, repetitive thoughts and behaviors, psychosis, anger, somatic symptoms, and substance use. Each item investigates whether and how often the participant has noticed and been disturbed by the symptom in the last 2 weeks (American Psychiatry Association [APA], 2013). Considering the research purpose, participants were excluded from data analysis only when presenting symptoms in more than two domains or when psychosis, dissociation or substance abuse were singly present.

Socio-Demographic Questionnaire

The socio-demographic questionnaire provided socio-demographic data of the participants such as age, color, gender, self-reported laterality and also information regarding the use of medications, physical activities and if they perceived intense variation in their weight for the last 5 years.

Experiments

Two experimental tasks were performed by participants. Both tasks were programmed in OpenSesame (version 3.1.9 – Mathôt et al., 2012). Stimuli were presented on a 25" widescreen computer screen (60 Hz), in black background, with a resolution of 2560 × 1080 pixels. Eighteen experimental files were prepared, nine for male participants and nine for female participants, one file for each silhouette size. All participants performed and successfully passed a task comprehension test before starting the experiment and sat at a constant 50 cm distance of the computer screen.

Experiment 1

The first experiment consisted of 90 trials randomly presented including six silhouette stimuli: two hominid silhouette stimuli (Australopithecus), two homo sapiens silhouette stimuli (male or female, depending on participant's gender), one silhouette of a monkey and one silhouette of a broom. With the exception of the broom, the images used in the experimental task were taken from the PhyloPic database and handled in Photoshop CS5 software. Each stimulus was presented 15 times and were each exposed at a constant 17 ms interval. After the presentation of each target stimulus, an oval-shaped visual noise was presented, pixelated in a Gaussian format at 350p×, for a constant interval of 116 ms. This interval is based on previous studies on perception and awareness of simple visual stimuli (Pessoa et al., 2005).

Before each silhouette stimulus presentation, a fixation stimulus (white 4p× cross) was shown for a constant interval of 500 ms. After each silhouette stimulus participant informed by mouse response which image they had just seen, if "a homo sapiens," "a monkey," "a hominid" or a "broom." A response timeout of 3500 ms was established for each trial. After the first response, a second response regarding the same trial was requested, in which participants should judge the clarity of his visual experience for each trial. A four point-scale of Perceptual Awareness Scale (PAS) was applied (Ramsøy and Overgaard, 2004). A response timeout of 3500 ms was also established for this response (**Figure 1A**). Unanswered trials for the first response were considered omission trials. This experiment had a self-controlled rest interval after 45 trials.

Experiment 2

The second experiment consisted of 280 trials randomly presented in two counterbalanced blocks. In one block silhouette stimuli were presented at a regular spatial orientation (140 trials), while in the other block stimuli were rotated at 180° (140 trials). Participants task was to estimate body silhouettes

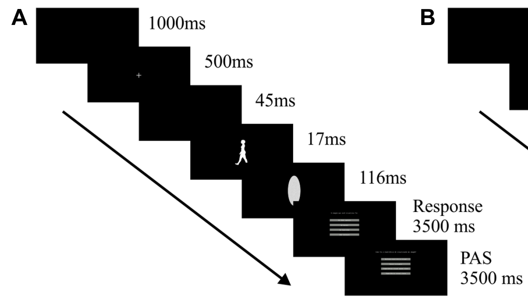

FIGURE 1 | (A) Trial sequence for experimental task 1 and **(B)** trial sequence for experimental task 2.

size in relation to their own body size. Seven images of the FRS were applied: the two extremes of the scale (extremely thin silhouette and extremely obese silhouette), a silhouette referring to the own real body size chosen by participant's at the conventional FRS application before experimental tasks, two silhouettes immediately below the own real body size and two silhouettes immediately above the own real body size as informed by participant's previously to the experimental tasks.

Each stimulus was presented 20 times at a constant 17 ms interval in a random order for each block. After the presentation of each stimulus, an oval-shaped noise pixelated in a Gaussian format at 350p× was presented at a constant 116 ms interval (Pessoa et al., 2005). After the stimulus presentation, a response screen requested participants to answer the similarity of the visualized silhouette figure in comparison to their own body. Accurate responses were only considered when participants matched the stimuli presentation with the stimuli description (e.g., much thinner stimulus within seven possible stimuli with "Much Thinner" response option). Accurate "Equal" responses occurred when equal response were given to the silhouette stimulus correspondent to the one selected as the participants' current body in the pre-experiment FRS application. By means of mouse response on seven-point scale participants selected one of the following options regarding their own body size: "much thinner," "thinner," "relatively thinner," "equal," "relatively larger," "larger" and "much larger." The response screen was displayed for 3500 ms and participants were asked to respond as quickly as possible (**Figure 1B**). Unanswered trials were considered omission trials. Rest intervals were taken between and within the midpoint of each block.

Procedure

Participants were invited to participate in the experiment by a pre-scheduled agenda at the laboratory room. Before conducting any research procedure, the participants were instructed on the objectives and ethical aspects of the research and were presented to the Informed Consent Form (ICF). In case of agreement to participate, the data collection procedures were initiated.

The data collection procedure was: (1) pre-test with the conventional application of the FRS; (2) first experimental task; (3) second experimental task; (4) response to the Socio-Demographic Questionnaire, DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure – Adult and BSQ; (5) BMI measurement, performed with a stadiometer (Brand: WCS/Cardiomed) and a body weight balance (Brand: Plenna); and (6) closing conversation about the data collection. Data collection lasted approximately 50 min.

Group Formation

For the constitution of satisfied/dissatisfied groups and with distortion/without body image distortion, a FRS cut-off point based in previous experimental research was adopted (Pinhatti et al., 2018). Thus, participants who scored −1, 0 and 1 in the FRS, which corresponds to a variation of ± 5 kg/m2 (two times own silhouette figure variance) in relation to their BMI were considered satisfied and without body image distortion. On the other hand, participants with scores of −5, −4, −3, −2, 2, 3, 4, and 5 on both FRS scores were placed into the dissatisfaction and body image distortion groups, since they represent real body size (perception) and ideal body size (satisfaction) above ± 5 kg/m2 of variation in relation to their own bodies.

Statistical Analysis

Experimental data was automatically transferred by the OpenSesame software to individual Excel worksheets (Microsoft) and then transferred to IBM SPSS (version 25) for statistical analysis. Descriptive analysis was carried out to observe the distribution of data normality. Trial response below 300 ms and above 3500 ms were considered invalid. Participants with an invalid trial rate above 10% were excluded from the study (Wang et al., 2012). Included participants in the study had an average of 1.07% (SD = 1.54%) invalid trials.

Experiment 1

The analysis of Experiment 1 consisted of three independent measures *t* tests for accuracy and RT as dependent variables between independent variables men and women, satisfaction and body dissatisfaction groups, and distorted and undistorted body image groups. Oneway variance analysis (ANOVA) considering stimuli class as independent variable were also performed to compare dependent variables accuracy and RT of the image discrimination and response time for visual clarity experience (PAS) response. The Bonferroni correction was used for this analysis. We also performed correlation analysis between BMI, BSQ scores, distortion and body dissatisfaction scores from the FRS and the task accuracy scores.

Experiment 2

The analysis of Experiment 2 consisted of three 2 × 2 mixed ANOVAs, considering dissatisfaction/satisfaction, distorted/undistorted body image groups, and men/women as intersubjective factors (one for each ANOVA) and block of normal presentation of the stimuli/block of inverted presentation of the stimuli as the within subject factor. Dependent variables for these analyses were accuracy and RT to the stimuli set. We also performed *t*-tests for independent groups taking distorted × undistorted body image groups and unsatisfied × satisfied body image groups as independent variables and accuracy means for each of the seven silhouette figures as dependent variable. Correlation analysis between accuracy, BMI, BSQ scores, distortion scores and body dissatisfaction from the FRS were also performed.

RESULTS

Experiment 1

General accuracy rate for all figures was 69.1%. Specific ratings were 97.8% for broom, 74.9% for homo sapiens, 65.8% for monkey and 51.1% for hominid silhouette. No differences in performance were found between male and female participants [$t(29) = 0.82$, $p = 0.936$]. When considering satisfaction and body dissatisfaction groups, based on the FRS scores, group comparison did not indicate differences for the overall performance between groups [$t(29) = -1.109$, $p = 0.277$]. However, specifically for the identification of human figure, body dissatisfaction group presented a higher accuracy mean compared to the body satisfaction group [$t(29) = -1.919$, $p = 0.041$, $d = -0.73$]. In contrast, no differences were found between groups of body image distortion for this task [$t(29) = 1.499$, $p = 0.145$].

ANOVA testing for differences in accuracy, RT and RT for visual clarity experience between stimuli classes indicated a significant effect [$F(3,120) = 14.973$, $p < 0.001$, $f = 0.647$]. Bonferroni *post hoc* test evidenced that the broom stimulus was significantly more identified, and faster responded (RT and visual clarity experience RT) in relation to the other three stimuli classes. Homo sapiens stimulus was also more recognized than the hominid stimulus ($p = 0.006$, $d = 0.78$).

Correlation analysis evidenced a strong positive correlation between accuracy and visual clarity of stimuli measured by PAS ($r = 0.86$, $p < 0.001$). There was also a strong positive correlation between RT for stimulus identification and RT for visual clarity of the stimuli ($r = 0.73$, $p < 0.001$). **Figure 2** presents the accuracy rate average throughout the trial sequence for this experiment.

Experiment 2

Mixed ANOVAs for Body Image and Gender Groups

General accuracy rate for body silhouette figures was 41.1%. **Table 1** presents body image and gender groups means and results for the mixed ANOVA's. Comparison of the general accuracy rate between regular and inverted stimuli orientation blocks showed significant difference [$t(29) = 2.528$, $p = 0.014$, $d = 0.64$], with greater accuracy in the regular orientation block ($M = 43.97\%$, SD = 8.86%) than in the inverted orientation block ($M = 38.23\%$, SD = 9.03%). Gender differences were found with higher accuracy rates observed for women. A Mixed ANOVA revealed a main effect for both gender group and stimuli orientation block, but no interaction between these variables.

Assumptions for the equality of variances and covariances matrices were all met for the performed Mixed ANOVAs. Regarding groups established based on the explicit body dissatisfaction criteria, a mixed ANOVA did not indicate general performance effect between groups, nor an interaction of the performance of the groups with stimuli orientation blocks. However, considering only the performance between blocks per group, an effect is observed, which is explained by a performance difference observed specifically for the satisfied group.

In turn, a mixed ANOVA based on body image distortion groups showed an effect of stimulus orientation on task performance and an effect of the distortion group on task performance. However, no interaction effect was observed between these variables for the mixed model. Both groups presented higher accuracy rates for stimulus recognition in the regular stimuli orientation block than in the inverted stimuli presentation. Also the distorted body image group presented a significantly higher accuracy index than the non-distorted body image group when considering all trials together [$t(29) = -2.861$, $p = 0.008$, $d = -1.04$].

Comparisons for Specific Silhouette Figures Accuracy

In the analyses considering the explicit criteria for groups' composition, a difference was found only for one silhouette figure between distorted and undistorted body image groups, as indicated in **Figure 3**. The distorted body image group had higher accuracy rate for the much thinner figure, both in the regular stimuli orientation [$t(29) = -3.145$, $p = 0.004$, $d = -1.15$] and in the inverted stimuli orientation experimental blocks [$t(29) = -4.933$, $p < 0.001$, $d = -1.81$].

BSQ, BMI and Reaction Time Analyses

Differences between satisfied and dissatisfied body image groups were only observed in the scores of BSQ dimensions "self-perception of body shape" [$t(29) = -2.870$, $p = 0.008$, $d = -1.028$] and "comparative perception of body image" [$t(29) = -2.562$, $p = 0.02$, $d = -97$]. Dissatisfied body image participants had higher averages in these scores. The mean BMI of dissatisfied participants was also higher than that of satisfied participants [$t(29) = -2.484$, $p = 0.019$, $d = 1$].

Regarding the average RT performance per group, no difference was found between men and women [$t(29) = 0.028$, $p = 0.978$], between distorted and undistorted groups [$t(29) = 0.861$, $p = 0.396$] and between satisfied and dissatisfied with body image groups [$t(29) = -0.831$, $p = 0.413$]. As presented in **Figure 4**, accuracy average throughout the trial

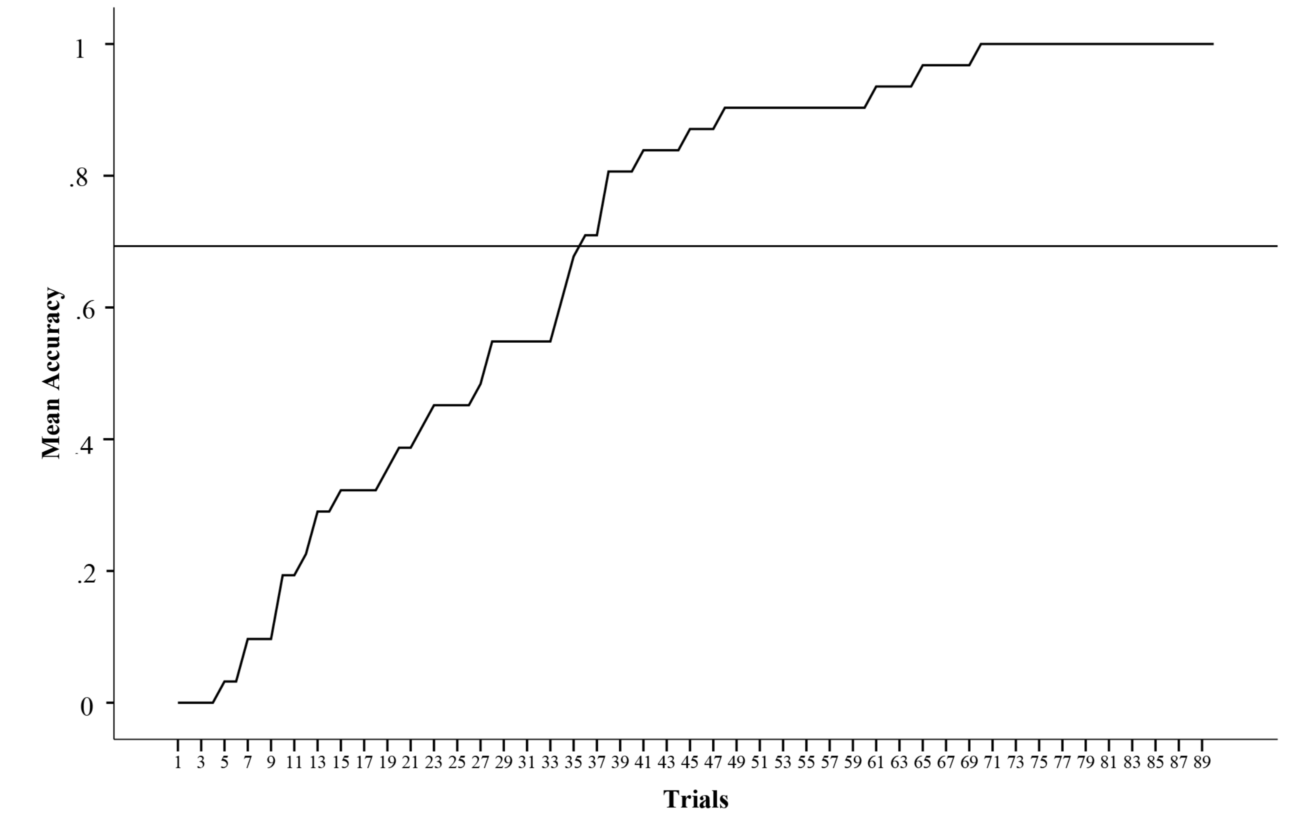

FIGURE 2 | Accuracy average compiled for experimental task 1.

sequence in this experiment is not crescent as it was observed in Experiment 1.

DISCUSSION

The experiments performed in this study required participants to discriminate general silhouettes (Experiment 1) and to judge whether the size of body silhouettes was similar in relation to their own body (Experiment 2). Accuracy rates in both tasks indicated that participants were able to recognize silhouettes at 17 ms, being more successful in the first task. Although previous literature has reported that at 17 ms few subjects were able to visually detect body stimuli (Pessoa et al., 2005), results from our study showed an overall accuracy of 63.9% for body silhouettes recognition considered alone. However, when asked to correctly judge the size of body silhouettes compared to their own body the accuracy rate dropped to 41.1%. In regard to visual clarity experience (PAS), scores from the first experiment suggested that visual experience was associated with the accuracy index, which is in agreement with previous results (Sandberg et al., 2010).

TABLE 1 | Body image and Gender groups means and standard deviations with correspondent Mixed ANOVAs statistics for Experiment 2.

	Regular	Rotated	Comparisons	*F(df)*	η^2
Body Satisfied	43.01 (2.1)	35.07 (2.1)	Satisfied × Dissatisfied	0.56 (1,29)	0.01
Body Dissatisfied	42.91 (2.5)	39.45 (2.4)	Regular × Rotated	12.53** (1,29)	0.30
			Interaction	1.93 (1,29)	0.06
Body Undistorted	40.75 (2.1)	33.15 (1.9)	Undistorted × Distorted	6.66* (1,29)	0.18
Body Distorted	45.66 (2.3)	41.48 (2.1)	Regular × Rotated	13.27** (1,29)	0.31
			Interaction	1.11 (1,29)	0.03
Men	37.67 (2.2)	32.20 (2.4)	Men × Women	10.85** (1,29)	0.27
Women	46.31 (1.8)	39.88 (1.9)	Regular × Rotated	12.52** (1,29)	0.30
			Interaction	0.08 (1,29)	0.00

$^{*}p < 0.05$, $^{**}p < 0.001$.

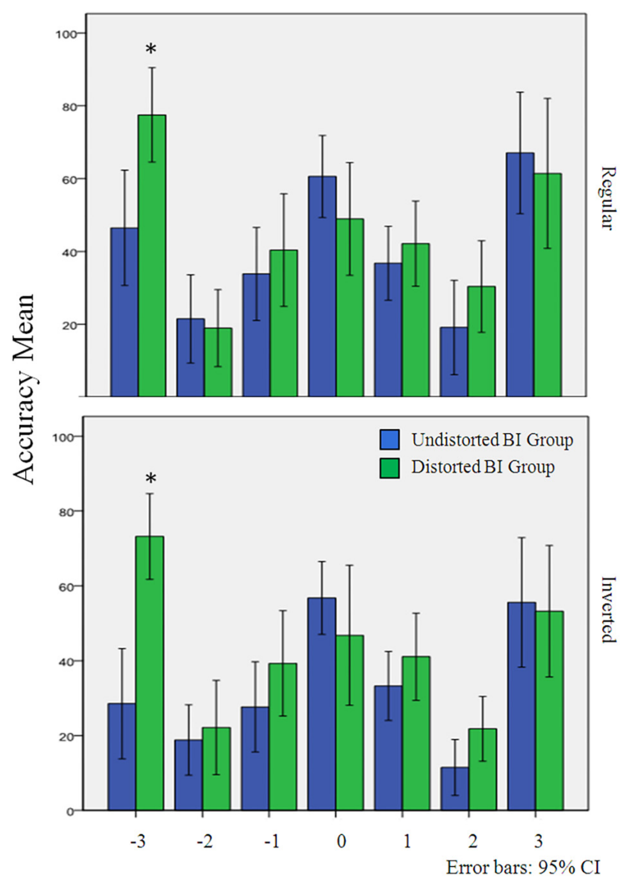

FIGURE 3 | Accuracy averages of BI perceptual groups divided by silhouette figure and experimental condition in Experiment 2. Confidence interval of 95%. *$p < 0.05$.

Results from the first experiment did not present effect considering explicit body image group criteria, which suggests that the attitude or perception toward own body does not produce performance differences for neutral stimuli discrimination. However, greater accuracy for the human silhouette recognition in the dissatisfied body image group is in agreement with evidences from attentional bias research that has shown higher levels of body stimuli recognition for dissatisfied body image groups in both clinical (Forghieri et al., 2016) and non-clinical settings (Glauert et al., 2010).

Yet this observed difference for body image groups was not confirmed in the context of body size judgment. Experiment 2 demonstrated that satisfied and dissatisfied body image participants had no differences in size judgments performance. Instead body image distortion served as a more differential explicit criterion. Subjects with higher rates of body image distortion presented greater accuracy for body silhouette recognition at 17 ms, with a tendency to better recognize thinner silhouettes. Such evidence suits as a better evidence of attention toward bodies, once it discriminates the direction of same class stimuli size recognition. This tendency was maintained when stimuli were inverted, which may signalize a top-down process. Differences in general performance between experimental blocks, considering the stimuli orientation, also reinforces the notion that a top-down process could be involved in the size judgment task. Stimuli set variations in size occur in a horizontal plane. By rotating the silhouette figures in 180° the size of the same stimuli set in regular position remained the same. So, if no human body feature identification had interfered in the size judgments, the rotation of stimuli would not had impacted the accuracy results. However, by inverting the stimuli set we have observed a reduction in participants' accuracy rates.

To better discriminate thinner bodies had already been observed in non-clinical groups for intervals greater than 150 ms (Glauert et al., 2010; Joseph et al., 2016). However, results from these researches are contradictory since body dissatisfaction was negatively correlated with attentional bias toward thin bodies in one study (Glauert et al., 2010) and predicted attentional bias for thin bodies in the other study (Joseph et al., 2016). Differences may be explained by contrasting experimental paradigms applied, since exposure times to body silhouettes varied between 150 and 500 ms. In any case, our results did not replicate such effects once distortion of body image, not dissatisfaction, was the decisive discriminator factor for judgment performance. The lack of difference between satisfied and dissatisfied body image groups may suggest that this type of classification is more valid when comparing conscious body image assessment. This can be corroborated by the positive and significant correlations observed between attitudinal body image scores and the BSQ scores, which is in line with previous results (Fisher et al., 2019). Participants in the dissatisfied group presented higher BMI, which is also in agreement with previous research (Pull and Aguayo, 2011).

When accounting for the perceptual discrepancies between distorted and undistorted body image groups, it is interesting to note that Figure Rating Scales suggest that individuals who choose discordant figures from their actual body size as being their own body would have poorer decision making in perceptual body identification. Nevertheless, when comparing the accuracy rates specifically to their own body size figures the undistorted body image group had better scores than the distorted body image group, even though such difference was not significant. In this sense perceptual mistakes would be restricted to own body identification, but not to ideal silhouettes such as thinner bodies. However, more research should aim to better investigate such differences.

In regard to participants gender, in the first experiment no differences were found for accuracy rates. In the second experiment good accuracy rates were observed for men and women, although the latter presented greater general accuracy both in regular and inverted stimuli orientation. These results point to a gender difference in reference to body image assessment, which has been widely discussed in this literature (e.g., Muth and Cash, 2006; Alfano et al., 2011).

Responses for both tasks can be further discussed on what has been described as the "exposure effect" in visual perception literature. Usually, correct responses in recognition of neutral stimuli for brief interval exposure is increased over a number of trial sequence. Even in the absence of an explicit awareness of stimuli, discrimination still seems to get better

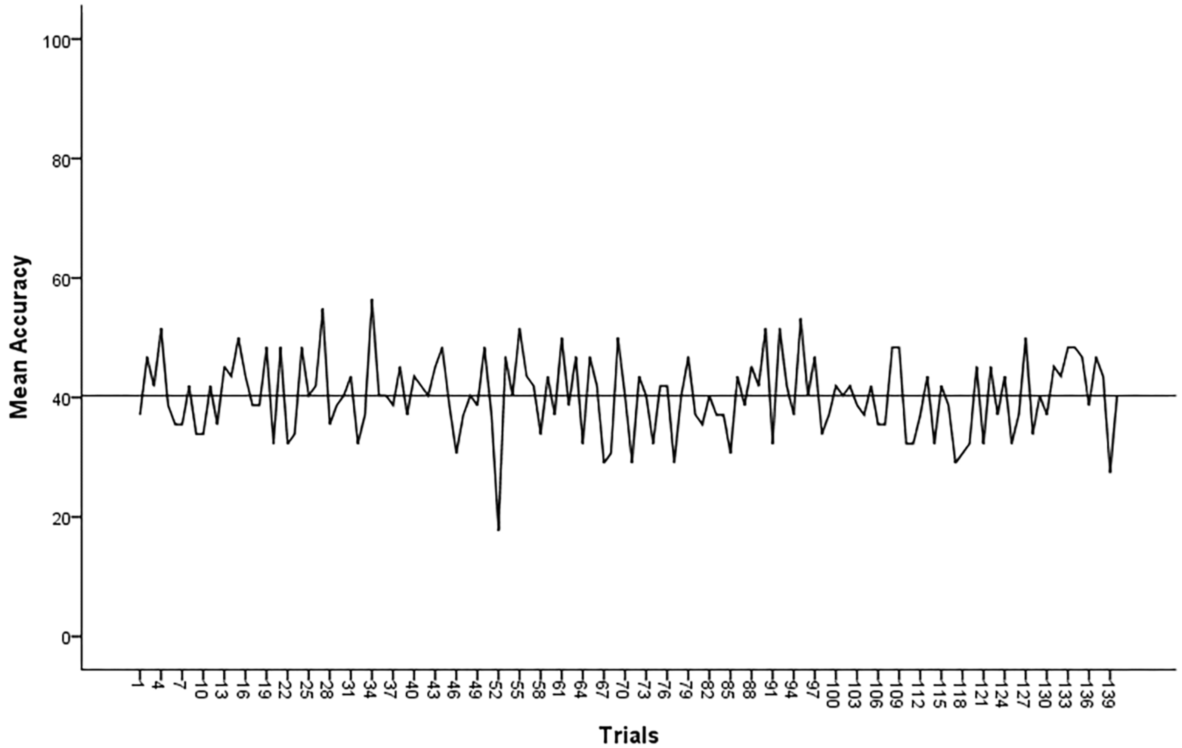

FIGURE 4 | Accuracy average compiled for experimental task 2.

over repeatedly exposure (Seamon et al., 1984). The most common interpretation for this phenomenon suggests that an affective mechanism operates a detection specification at the initial processing of visual information, aiding in the increase of accuracy through repetition. An alternative interpretation to the exposure effect is that for it to occur a previous awareness of the presented stimuli is necessary, which will account for a preference effect increasing accuracy (Zilva et al., 2013). Our results denoted an exposure effect solely for the first experiment, which contrasts to the previous stimuli awareness hypothesis. Participants in this study had already been exposed to the set of stimuli in Experiment 2 when responding to the FRS previously to experiments. Perhaps because the stimuli used in the second experiment were not exactly neutral, miscellaneous responses prevented a clear exposure effect. However, the absence of incremental accuracy in this experiment could be either explained by the lower accuracy rates observed compared to the first experiment rates. In any case more research should aim to investigate the exposure effect specifically for body silhouettes stimuli.

CONCLUSION

Results indicated an inversion effect of silhouette figures recognition at 17 ms and differences of performance between distorted and undistorted body image groups. In addition, it has evidenced a specific effect of accuracy for silhouette figures thinner than the participants' own body in the distorted body image group. These results may help to understand the contrast between attitudinal and perceptual aspects of body image at initial stages of visual processing. Implications could be extended to better refine the definition of body image perception and to further explore the associations between visual attention toward bodies and attitudinal/emotional components of body image. In line with continuous models of body representation and consciousness of the body, the present study offers evidence that fast body size judgment responses are partially associated with explicit body size judgments.

The present study had methodological limitations, such as the absence of a clinical comparison group, heterogeneous sample size groups between men and women, and the lack of a longer exposure interval to compare with the observed evidence at 17 ms. Further investigation should aim to compare temporal exposure intervals within implicit detection to look for perceptual differences regarding body size judgment in clinical groups. Also, it would be important to look for perceptual specificities in eating disorders population, once these groups could benefit from interventions focusing on implicit cognition. Considering that a specific trend toward thinner bodies was observed within distorted body image group it would be important to explore if such trend is also present in eating disorders population, specifically in anorexic patients.

Future studies should seek to continue refining experimental paradigms to investigate brief exposure intervals for body stimuli size judgment. Use of complex and simple body visual stimuli should also be addressed by comparing photograph stimuli to silhouette stimuli in rigorously controlled experiments.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation, to any qualified researcher upon request.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the American Psychological Association. All subjects gave written informed consent in accordance with the Declaration of Helsinki and Brazilian regulation for studies with human participants (Resolution 510/2016 of the National Health Council). The protocol was reviewed and approved by the Ethics Committee from the Federal University of Rio Grande do Sul. All participants provided informed consent.

AUTHOR CONTRIBUTIONS

All authors conceived the research project, designed the experimental material, and contributed to the writing of the manuscript. AN and VE collected the data. TD conducted the analyses.

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REFERENCES

Alfano, L., Hildebrandt, T., Bannon, K., Walker, C., and Walton, K. E. (2011). The impact of gender on the assessment of body checking behavior. *Body Image* 8, 20–25. doi: 10.1016/j.bodyim.2010.09.005

American Psychiatry Association [APA] (2013). *Diagnostic and Statistical Manual of Mental disorders – DSM-5*. 5th Edn. Washington: American Psychiatric Association.

Bailey, K. A., Gammage, K. L., and van Ingen, C. (2017). How do you define body image? Exploring conceptual gaps in understandings of body image at an exercise facility. *Body Image* 23, 69–79. doi: 10.1016/j.bodyim.2017.08.003

Barra, J., Senot, P., and Auclair, L. (2017). Internal model of gravity influences configural body processing. *Cognition* 158, 208–214. doi: 10.1016/j.cognition.2016.10.018

Bedford, R., Wagner, N. J., Rehder, P. D., Propper, C., Willoughby, M. T., and Mills-Koonce, R. W. (2017). The role of infantsŠ mother-directed gaze, maternal sensitivity, and emotion recognition in childhood callous unemotional behaviours. *Eur. Child Adolesc. Psychiatry* 26, 947–956. doi: 10.1007/s00787-017-0967-1

Bonemei, R., Costantino, A. I., Battistel, I., and Rivolta, D. (2018). The perception of (naked only) bodies and faceless heads relies on holistic processing: evidence from the inversion effect. *Br. J. Psychol.* 109, 232–243. doi: 10.1111/bjop.12271

Botvinick, M., and Cohen, J. (1998). Rubber hands 'feel' touch that eyes see. *Nature* 391, 756–756. doi: 10.1038/35784

Cardinali, L., Brozzoli, C., Luauté, C., Roy, A. C., and Farnè, A. (2016). Proprioception is necessary for body schema plasticity: evidence from a deafferented patient. *Front. Hum. Neurosc.* 10:272. doi: 10.3389/fnhum.2016.00272

Caspi, A., Amiaz, R., Davidson, N., Czerniak, E., Gur, E., Kiryati, N., et al. (2017). Computerized assessment of body image in anorexia nervosa and bulimia nervosa: comparison with standardized body image assessment tool. *Arch. Wom. Ment. Health* 20, 139–147. doi: 10.1007/s00737-016-0687-4

Castellini, G., Polito, C., Bolognesi, E., D'Argenio, A., Ginestroni, A., Mascalchi, M., et al. (2013). Looking at my body. Similarities and differences between anorexia nervosa patients and controls in body image visual processing. *Eur. Psychiatry* 28, 427–435. doi: 10.1016/j.eurpsy.2012.06.006

Cooper, P. J., Taylor, M. J., Cooper, Z., and Fairburn, C. G. (1987). The development and validation of the body shape questionnaire. *Int. J. Eat. Disord.* 6, 485–494. doi: 10.1002/1098-108x(198707)6:4<485::aid-eat2260060405>3.0.co;2-o

Cornelissen, K. K., Widdrington, H., McCarty, K., Pollet, T. V., Tovée, M. J., and Cornelissen, P. L. (2019). Are attitudinal and perceptual body image the same or different? Evidence from high-level adaptation. *Body Image* 31, 35–47. doi: 10.1016/j.bodyim.2019.08.001

D'Amour, S., and Harris, L. R. (2017). Perceived face size in healthy adults. *PLoS One* 12:e0177349. doi: 10.1371/journal.pone.0177349

DeVignemont, F., and Alsmith, A. (2017). *The Body and the Self, Revisited*. Cambridge, MA: The MIT Press.

Di Pietro, M., and Silveira, D. X. (2009). Internal validity, dimensionality and performance of the body shape questionnaire in a group of Brazilian college students. *Rev. Bras. Psiquiatria* 31, 21–24. doi: 10.1590/S1516-44462008005000017

Duncum, A. J. F., Atkins, A. J. F., Beilharz, F. L., and Mundy, M. E. (2016). Abnormalities in the visual processing of viewing complex visual stimuli amongst individuals with body image concern. *Adv. Cog. Psychol.* 12, 39–49. doi: 10.5709/acp-0185-0

Ferrer-García, M., and Gutiérrez-Maldonado, J. (2008). Body image assessment software: psychometric data. *Behav. Res. Methods* 40, 394–407. doi: 10.3758/BRM.40.2.394

Fisher, S., Abdullah, A., Charvin, I., Da Fonseca, D., and Bat-Pitault, F. (2019). Comparison of body image evaluation by virtual reality and paper-based figure rating scales in adolescents with anorexia nervosa: retrospective study. *Eat Weight Disord.* doi: 10.1007/s40519-019-00680-1 [Epub ahead of print].

Forghieri, M., Monzani, D., Mackinnon, A., Ferrari, S., Gherpelli, C., and Galeazzi, G. M. (2016). Posturographic destabilization in eating disorders in female patients exposed to body image related phobic stimuli. *Neurosci. Lett.* 629, 155–159. doi: 10.1016/j.neulet.2016.07.002

Gallagher, S. (1986). Body image and body schema: a conceptual clarification. *J. Mind Behav*. 7, 541–554.

Gardner, R. M., and Boice, R. (2004). A computer program for measuring body size distortion and body dissatisfaction. *Behav. Res. Methods Instrum. Comput.* 36, 89–95. doi: 10.3758/BF03195553

Glauert, R., Rhodes, G., Fink, B., and Grammer, K. (2010). Body dissatisfaction and attentional bias to thin bodies. *Int. J. Eat. Disord.* 43, 42–49. doi: 10.1002/eat.20663

Griep, R. H., Aquino, E. M. L., Chor, D., Kakeshita, I. S., Gomes, A. L. C., and Nunes, M. A. A. (2012). Confiabilidade teste-reteste de escalas de silhuetas de autoimagem corporal no *Estudo Longitudinal de Saúde do Adulto*. *Cad. Saúde Pública* 28, 1790–1794. doi: 10.1590/S0102-311X2012000900017

Joseph, C., LoBue, V., Rivera, L. M., Irving, J., Savoy, S., and Shiffrar, M. (2016). An attentional bias for thin bodies and its relation to body dissatisfaction. *Body Image* 19, 216–223. doi: 10.1016/j.bodyim.2016.10.006

Kakeshita, I. S., Silva, A. I. S., Zanatta, D. P., and Almeida, S. S. (2009). Construção e fidedignidade teste-reteste de escalas de silhuetas brasileiras para adultos e crianças. *Psic. Teor. Pesq.* 25, 263–270. doi: 10.1590/S0102-37722009000200016

Kling, J., Kwakkenbos, L., Diedrichs, P. C., Rumsay, N., Frisén, A., Brandão, M. P., et al. (2019). Systematic review of body image measures. *Body Image* 30, 170–211. doi: 10.1016/j.bodyim.2019.06.006

Lamberts, K., Brockdorff, N., and Heit, E. (2002). Perceptual processes in matching and recognition of complex pictures. *J. Exp. Psychol. Hum. Percept. Perform.* 28, 1176–1191. doi: 10.1037/0096-1523.28.5.1176

Leehr, E., Giel, K. E., Schaeffeler, N., Mack, I., Thiel, A., Zurstiege, G., et al. (2018). Where do you look? visual attention to human bodies across the weight spectrum in individuals with normal weight or with obesity. *Obes. Facts* 11, 277–286. doi: 10.1159/000489787

Longo, M. R., and Haggard, P. (2010). An implicit body representation underlying human position sense. *Proc. Natl. Acad. Sci. U.S.A.* 107, 11727–11732. doi: 10.1073/pnas.1003483107

Longo, M. R., and Haggard, P. (2012). Implicit body representations and the conscious body image. *Acta Psychol.* 141, 164–168. doi: 10.1016/j.actpsy.2012.07.015

Martel, M., Cardinali, L., Roy, A. C., and Fairè, A. (2016). Tool-use: an open window to body representation and its plasticity. *Cogn. Neuropsychol.* 33, 82–101. doi: 10.1080/02643294.2016.1167678

Mathôt, S., Schreij, D., and Theeuwes, J. (2012). OpenSesame: an open-source, graphical experiment builder for the social sciences. *Behav. Res. Methods* 44, 314–324. doi: 10.3758/s13428-011-0168-7

Menzel, J. E., Krawczyk, R., and Thompson, J. K. (2011). "Attitudinal assessment of body image for adolescents and adults," in *Body Image: A handbook of Science, Practice and Prevention*, 2 Edn, eds T. Cash, and L. Smolak, (New York, NY: The Guilford Press), 182–186.

Merleau-Ponty, M. (2006). *Fenomenologia da Percepção*. São Paulo: Martins Fontes.

Mölbert, S. C., Klein, L., Thaler, A., Mohler, B. J., Brozzo, C., Martus, P., et al. (2017). Depictive and metric body size estimation in anorexia nervosa andbulimia nervosa: a systematic review and meta-analysis. *Clin. Psychol. Rev.* 57, 21–31. doi: 10.1016/j.cpr.2017.08.005

Moussally, J. M., Brosch, T., and Van der Linden, M. (2016). Time course of attentional biases toward body shapes: the impact of body dissatisfaction. *Body Image* 19, 159–168. doi: 10.1016/j.bodyim.2016.09.006

Muth, J. L., and Cash, T. F. (2006). Body-image attitudes: what difference does gender make? *J. Appl. Soc. Psychol.* 27, 1438–1452. doi: 10.1111/j.1559-1816.1997.tb01607.x

Palumbo, L., Ogden, R., Makin, A. D. J., and Bertamini, M. (2014). Examining visual complexity and its influence on perceived duration. *J. Vis.* 14, 1–18. doi: 10.1167/14.14.3

Pessoa, L., Japee, S., and Ungerleider, L. G. (2005). Visual awareness and the detection of fearful faces. *Emotion* 5, 243–247. doi: 10.1037/1528-3542.5.2.243

Pinhatti, M. M., DeCastro, T. G., and Gomes, W. B. (2018). Body image perception and sense of agency: notes from the alien hand experiment. *Psico* 49, 111–118. doi: 10.15448/1980-8623.2018.2.28589

Pitron, V., Alsmith, A., and deVignemont, F. (2018). How do the body schema and the body image interact. *Conscious. Cogn.* 65, 352–358. doi: 10.1016/j.concog.2018.08.007

Pull, C. B., and Aguayo, G. A. (2011). Assessment of body-image perception and attitudes in obesity. *Curr. Opin. Psychiatr.* 24, 41–48. doi: 10.1097/YCO.0b013e328341418c

Ramsøy, T. Z., and Overgaard, M. (2004). Introspection and subliminal perception. *Phenomenol. Cogn. Sci.* 3, 1–23. doi: 10.1023/B:PHEN.0000041900.30172.e8

Rivolta, D., Lawson, R. P., and Palermo, R. (2017). More than just a problem with faces: altered body perception in a group of congenital prosopagnosics. *Q. J. Exp. Psychol.* 70, 276–286. doi: 10.1080/17470218.2016.1174277

Sandberg, K., Timmermans, B., Overgaard, M., and Cleeremans, A. (2010). Measuring consciousness: is one measure better than the other? *Conscious. Cogn.* 19, 1069–1078. doi: 10.1016/j.concog.2009.12.013

Schilder, P. (1999). *A Imagem Do Corpo: As Energias Construtivas Da Psique*. São Paulo, SP: Martins Fontes.

Seamon, J. G., Marsh, R. L., and Brody, N. (1984). Critical importance of exposure duration for affective discrimination of stimuli that are not recognized. *J. Exp. Psychol. Learn. Mem. Cogn.* 10, 465–469. doi: 10.1037/0278-7393.10.3.465

Sekunova, A., and Barton, J. J. S. (2008). The effects of face inversion on the perception of long-range and local spatial relations in eye and mouth configuration. *J. Exp. Psychol. Hum. Percept. Perform.* 34, 1129–1135. doi: 10.1037/0096-1523.34.5.1129

Smeets, M. A. M., and Panhuysen, G. E. M. (1995). What can be learned from body size estimation? It all depends on your theory. *Eat Disord: J. Treat. Prev.* 3, 101–114. doi: 10.1080/10640269508249153

Stoddard, J., Tseng, W.-L., and Kim, P. (2017). Association of irritability and anxiety with the neural mechanisms of implicit face emotion processing in youths with psychopathology. *JAMA Psychiatry* 74, 95–103. doi: 10.1001/jamapsychiatry.2016.3282

Stunkard, A., Sørensen, T., and Schulsinger, F. (1983). Use of the Danish adoption register for the study of obesity and thinness. *Res. Publ. Assoc. Res. Nerv. Ment. Dis.* 60, 115–120.

Thompson, P., and Wilson, J. (2012). Why do most faces look thinner upside down? *i-Perception* 3, 765–774. doi: 10.1068/i0554

Wang, Z., Buetti, S., and Lleras, A. (2012). Predicting search performance in heterogeneous visual search scenes with real-world objects. *Collabra* 3:6. doi: 10.1525/collabra.53

Zilva, D., Vu, L., Newell, B. R., and Pearson, J. (2013). Exposure is not enough: suppressing stimuli from awareness can abolish the mere exposure effect. *PLos One* 8:e77726. doi: 10.1371/journal.pone.0077726

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Female Body Dissatisfaction and Attentional Bias to Body Images Evaluated Using Visual Search

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One factor, believed to predict body dissatisfaction is an individual's propensity to attend to certain classes of human body image stimuli relative to other classes. These attentional biases have been evaluated using a range of paradigms, including dot-probe, eye-tracking and free view visual search, which have yielded a range of – often contradictory – findings. This study is the first to employ a classic compound visual search task to investigate the relationship between body dissatisfaction and attentional biases to images of underweight and with-overweight female bodies. Seventy-one undergraduate females, varying their degree of body dissatisfaction and Body Mass Index (BMI), searched for a horizontal or vertical target line among tilted lines. A separate female body image was presented within close proximity to each line. On average, faster search times were obtained when the target line was paired with a uniquely underweight or with-overweight body relative to neutral (average weight only) trials indicating that body weight-related images can effectively guide search. This *congruent* search effect was stronger for individuals with high eating restraint (a behavioral manifestation of body image disturbance) when search involved a uniquely underweight body. By contrast, individuals with high BMIs searched for lines more rapidly when paired with with-overweight rather than underweight bodies, than did individuals with lower BMIs. For *incongruent* trials – in which a unique body was paired with a distractor rather than the target – search times were indistinguishable from neutral trials, indicating that the deviant bodies neither compulsorily "captured" attention nor reduced participants' ability to disengage their attention from either underweight or with-overweight bodies. These results imply the existence of attentional strategies which reflect one's current body and goal-directed eating behaviors.

Keywords: visual search, attentional bias, body dissatisfaction, body image, body perception, body mass index

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INTRODUCTION

Body dissatisfaction refers to the negative subjective evaluation of one's own physical shape, weight, and body (Stice and Shaw, 2002; Joseph et al., 2016). With high prevalence amongst women, it is considered a significant predictor of several major health risks, including depression, obesity, body dysmorphic disorder, anorexia nervosa, and bulimia nervosa (Kanayama et al., 2001; Keel and Klump, 2003; Hildebrandt et al., 2011; Mond et al., 2013; Fiske et al., 2014). Research indicates that individuals experiencing high levels of body dissatisfaction have cognitive biases, which influence the way they perceive themselves and their environment. Information processing related to body shape and size is presumed to occur automatically and with minimal conscious attention (Williamson et al., 2004). Numerous findings indicate that attentional biases to body-related stimuli are moderated by the degree to which an individual self-reports body dissatisfaction. The specific nature of attentional bias toward external body stimuli remains unclear, and is the focus of the present study.

In the domain of eating disorders, attentional biases favoring certain classes of food-related word and/or image stimuli have been proposed to reflect cognitive tendencies that serve to maintain particular pathological eating behaviors (Cooper et al., 1992; Faunce, 2002). The empirical relationships between attentional bias and eating disorder symptomology have been studied using a range of experimental methods. One of the most well-studied of these is the Stroop color naming task. Stroop studies show that individuals with significant eating disorder symptomology are often slower than controls to name the color of disorder-relevant stimuli (for example, a food-related word or with-overweight[1] body image) than for the color-naming of disorder-neutral stimuli (Perpina et al., 1993; Walker et al., 1995; Sackville et al., 1998; Davidson and Wright, 2002).

These longer color naming latencies shown by subjects with high eating disorder symptomology are generally assumed to result from these subjects – either consciously or unconsciously – deploying a greater proportion of their limited attentional resources to the disorder-relevant stimulus compared to control subjects. It is unclear, however, whether this results from: (i) an attentional bias toward the disorder-relevant stimulus for those with high eating disorder symptoms (being more perceptually salient, for example); (ii) whether these subjects find it more difficult to disengage their attention from the disorder-relevant stimulus to the color naming task; or (iii) whether the disorder-relevant stimuli elicit a general degradation in performance for reasons possibly unrelated to attention.

Another task often used to investigate the relationship between attentional bias and eating disorder symptomology is the dot-probe task. The dot-probe paradigm involves the presentation of two stimuli (e.g., a thin-ideal body and a with-overweight anti-ideal body) displayed simultaneously for a brief duration (∼100–500 ms). Both of these images then disappear, one of them being replaced by a single target object (e.g., a line or an arrow) about which the participant is asked to make a simple perceptual judgment. Attentional bias is then calculated by comparing reaction times to judgments spatially associated with each class of body stimulus. A quicker reaction time to a target that replaces one type of stimulus (e.g., a with-overweight body) over another type (e.g., an underweight body) is interpreted as an attentional bias weighted toward the former stimulus.

Conceptually speaking, if the task also includes pairings with images that are neutral with respect to the dimension of interest (e.g., body fat), dot-probe tasks offer potential advantages over Stroop task in that they are able to disentangle attentional bias toward a particular class of stimulus from an ability to disengage attention from that stimulus (Jiang and Vartanian, 2018). Unfortunately, the results of these dot-probe studies are highly variable, conflicting and complex. Whereas some studies find associations between high body dissatisfaction and a reduced attentional bias toward underweight bodies (Glauert et al., 2010), others find apparently contradictory associations, with some associating body dissatisfaction with attentional biases toward images of bodies with-overweight (Glauert et al., 2010; Gao et al., 2013) and others attentional biases toward underweight body images (Cho and Lee, 2013; Joseph et al., 2016).

These apparent discrepancies may be accounted for by a range of methodological considerations. For example, taken as a whole, these studies employ a diverse array of body stimuli, including unclothed women (Glauert et al., 2010), clothed women with revealed torsos (Cho and Lee, 2013; Joseph et al., 2016), body parts varying in skin exposure, gesture and visual complexity (Gao et al., 2013, 2014). There is also considerable variation in the proportion of body fat represented in the images, particularly at the thin end of the spectrum (Glauert et al., 2010; Cho and Lee, 2013; Joseph et al., 2016). Such inconsistencies in the results of dot-probe experiments are not limited to the effects of body images. Indeed, Schmukle (2005) showed that dot-probe tasks offer very poor internal consistency and test–retest reliability. Eye-tracking studies have produced results broadly consistent with the idea that body dissatisfaction may be linked to some of the attentional biases described above, as evidenced through longer dwell times and more rapid fixation latencies toward both underweight and with-overweight body images relative to controls (Gao et al., 2013, 2014). In the absence of a clear and reliable relationship between the various measures of body dissatisfaction and attentional bias, however, we must consider other behavioral indices of attentional bias.

The other technique most commonly used by cognitive scientists to investigate attentional biases is visual search. In a standard visual search task observers are required to search for, and to make a perceptual judgment about, a uniquely defined target stimulus presented at some unknown location within an array of non-target (distractor) elements.

Few studies have applied the visual search paradigm to the question of attentional biases and body dissatisfaction (Jiang and Vartanian, 2018). Smeets et al. (2011) used an *odd-one-out* visual search task to examine attentional bias to body-related *words*, with body dissatisfaction induced through a body-checking priming manipulation. Those who had high body dissatisfaction showed speeded detection toward body-related words, compared to control conditions. Visual word stimuli, however, are known to recruit cortical mechanisms distinct from (but overlapping with) those involved in the processing of pictorial stimuli such as body stimuli (Downing et al., 2001; Taylor et al., 2007; Shinkareva et al., 2011; Park et al., 2014).

One study which did employ body images (Jiang and Vartanian, 2012) in conjunction with a visual search task, examined the extent to which participants' eye fixations were drawn to task-irrelevant images of average weight bodies, underweight bodies, and bodies with overweight, whilst searching for a non-body target (a blue triangle). They found that fixational dwell times were longer when presented in the context of underweight and with-overweight body images than

[1] The term, 'with-overweight' is used throughout this manuscript at the suggestion of a reviewer.

relative to non-body control images (signifying an attentional bias toward underweight and with-overweight bodies). No differences in dwell time were observed, however, for restrained and unrestrained eaters suggesting that visual search may be insensitive to differences in attentional biases in these two groups, should such differences exist. That said, the absence of such differences in attentional bias might be specific to the particular – and rather unconventional – *incidental fixation* measure used by Jiang and Vartanian (2012) to infer attentional bias. Whilst this incidental fixation task may be sensitive to the tendency of certain classes of body stimulus to involuntarily attract or capture subjects' visual attention, what it does not assess is the extent to which subjects might voluntarily deploy their attention toward a certain body type to accomplish their search task.

The present experiment employs a *compound visual task* – a variant of the classic *odd-one-out* visual search paradigm – to investigate attentional biases to images of underweight, with-overweight and average-weight female bodies. A compound search task is composed of a primary and a (more theoretically interesting) secondary stimulus. In our case the *primary* stimulus is a single horizontal or vertical "target" line presented within an array of nine obliquely oriented distractors ($\pm$10 degrees from vertical or horizontal). Importantly, the location of the target line is randomized from trial to trial. The search task measures the accuracy and speed with which participants are able to identify the orientation of the target line. It is important to note that the primary orientation identification task is used only as a means of indexing search performance. That it involves the perceptual analysis of orientation is assumed to be unrelated to the processing of the *secondary* stimulus. The *secondary* stimulus used here involves an array of female body images, with each body image presented immediately adjacent to a particular *primary* line stimulus. On any given trial, all bodies on the screen are identical (neutral body types) (**Figure 1A**), except for a subset of trials in which one morphologically distinct body (referred to as the *deviant* body) is presented. Here the term *deviant* has no pejorative implication, referring only to the fact that a particular body image is different from the other bodies on the screen. Half of the deviant bodies in our study are images of underweight female bodies (**Figures 1B,D**), and the other half are with-overweight female bodies (**Figures 1C,E**) (see section "Methods," for details). On the remaining trials (*neutral* trials), no underweight or with-overweight deviant bodies are presented. For *congruent* trials, an underweight or with-overweight deviant body is paired with the target line, with a neutral body paired with each distractor line (see **Figures 1B,C**). For *incongruent* trials the deviant body (underweight or with-overweight) is paired with a distractor line rather than the target line (see **Figures 1D,E**).

Attentional biases are inferred by comparing reaction times obtained on neutral trials to those obtained on congruent and incongruent trials. An advantage of the compound search paradigm over the conventional *odd-one-out* search paradigm is that it enables one to differentiate between attentional biases *toward* a given stimulus type (congruent effect) from subjects' ability to disengage and shift attention *away* from stimuli which may have otherwise "captured" attention (incongruent effect).

Unlike the incidental fixation search paradigm employed by Jiang and Vartanian (2012), the compound search task offers the additional advantage of being able evaluate the existence of any bias that subjects might have in their ability and/or preference to deploy their goal-directed attention in the direction of a certain class of target *congruent* secondary stimulus – be it an underweight or a with-overweight body.

If female observers are able to use variations in the visual representation of human body fat/shape to guide their visual search, then we predict that search times will be faster on *congruent* trials, in which a deviant underweight or with-overweight body is uniquely paired with the target line (congruent trials), than on neutral trials. Moreover, if underweight or with-overweight body images compulsorily capture observers' attention (i.e., without their conscious volition), such as is observed with "preattentive" visual features such as color or orientation singletons (Treisman and Gelade, 1980; Wolfe and Horowitz, 2004), we predict *search costs* on *incongruent* trials – i.e., slower search times on trials in which underweight or with-overweight bodies are uniquely paired with a distractor line compared to *neutral* trials in which no deviant body is presented.

In light of prior research demonstrating relationships between body dissatisfaction and attentional biases toward female body image-related stimuli (e.g., Glauert et al., 2010; Cho and Lee, 2013; Gao et al., 2013, 2014), this study also aims to: (i) establish whether attentional biases exist to both underweight and with-overweight body images; and (ii) determine whether the magnitudes of any such attentional biases in search performance are predicted by variations in female body dissatisfaction and/or BMI.

MATERIALS AND METHODS

Participants

The sample included 71 students enrolled in undergraduate courses at Western Sydney University, aged between 18 and 46 years (mean = 21.63, *SD* = 5.04). Country of birth included Australia (80%), Hong Kong, Afghanistan, Kuwait, India, Vietnam, Greece, South Africa, China, Sudan, Pakistan, Nepal, Kenya, and Iran. No participants reported color blindness. Each participants' height and weight were measured in order to calculate their BMI, which ranged from 16.21 to 46.29 kg/m^2 (mean = 26.21, *SD* = 6.33). Participants either received course credit for their involvement in the research study or they were offered monetary compensation for their time. The Western Sydney University Human Ethics Committee approved the study (approval number H1778). Prior to the study, the experimental tasks and research procedure were explained to the participants. All participants provided written informed consent before initiating the study.

Materials

Generation of the Figure Rating Scale

Fifteen computer generated female body images were designed and rendered using DAZStudio 4.9 Pro 3D modeling software

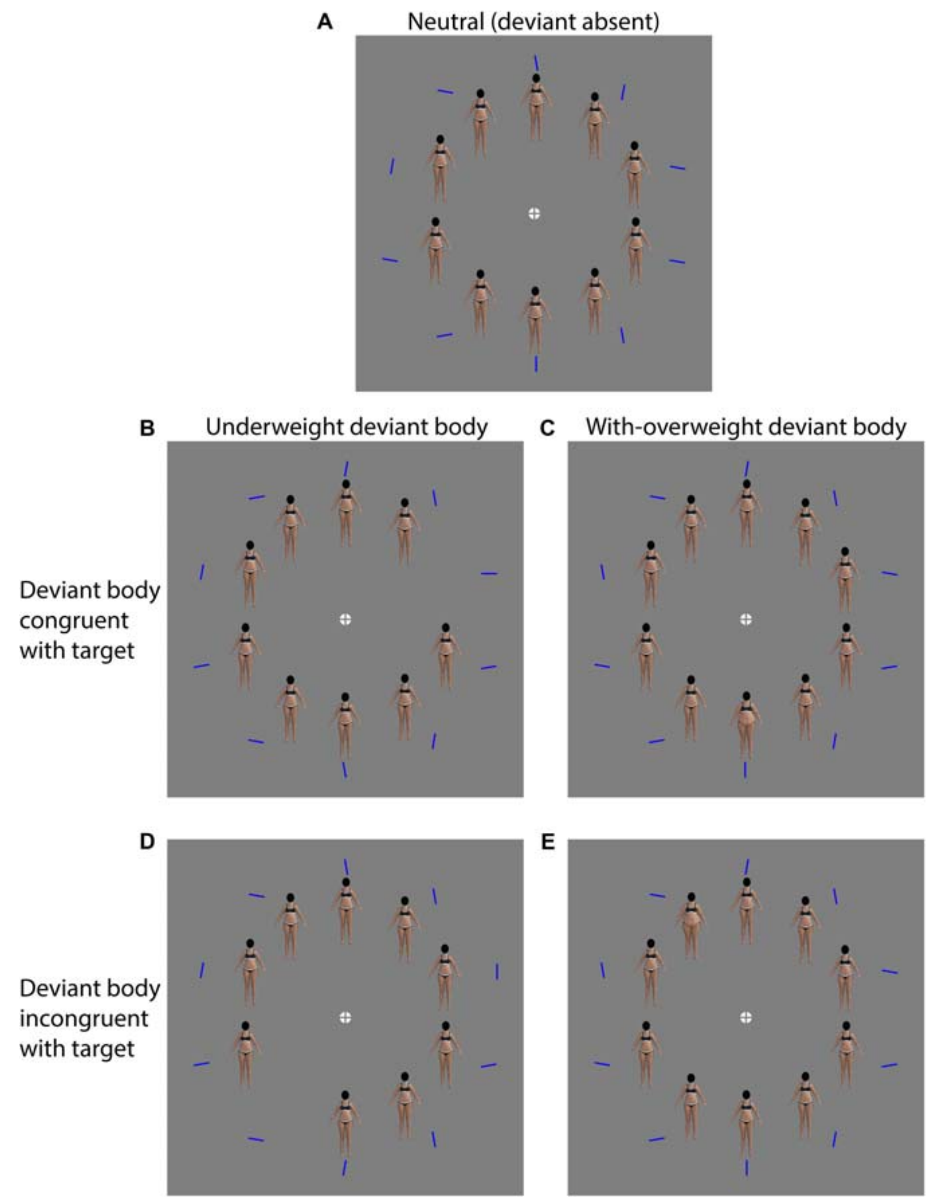

FIGURE 1 | Examples of each experimental condition used in the visual search task. **(A)** Neutral condition: all bodies correspond to "normal weight" BMI. **(B)** Underweight deviant body is congruent with the target location. **(C)** With-overweight deviant body is congruent with the target location. **(D)** Underweight deviant body is congruent with one of the distractors (i.e., target incongruent). **(E)** With-overweight deviant body is congruent with one of the distractors (i.e., target incongruent).

to simulate BMIs ranging from 12.51 to 41.23 kg/m^2. These body images were designed to simulate approximately equally spaced BMI categories ranging from emaciated (<15 kg/m^2), underweight (15–18.5 kg/m^2), through to normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (>30 kg/m^2). Previous research indicates that facial features draw attention away from the body (Gardner et al., 2009) and attract the greatest proportion of eye fixations relative to other body regions (Warschburger et al., 2015), so the head of each body stimulus was occluded by a black ellipse. The bodies were rendered with black underwear, exposing full legs, torso, arms, and neck, areas shown to be important in the determination of body ideals (Crossley et al., 2012). Nudity was avoided as this has been shown to trigger specific attentional processing, similar to aversive stimuli (Most et al., 2007).

Two pilot studies were run using eight participants to select body images corresponding to the BMI subcategories depicted in the Photographic Figure Rating Scale (PFRS) (Swami et al., 2008, 2012). The PFRS has good construct validity, convergent validity and test–retest reliability, and includes photographs of actual female bodies representing a range of physically measured BMIs (Swami et al., 2008, 2012). A printed A2 sized paper version of the

FIGURE 2 | Computer-rendered female body stimuli used in the Figure Rating Scale. Labels **A–J** correspond to bodies with increasing BMI.

PFRS scale was produced using the images of the PFRS ranging from emaciated (1; extreme left) to obese (10; extreme right).

Each of the fifteen rendered female body stimuli were printed onto a separate card and combined into a single deck. For each participant, this deck was shuffled and handed to them with each card shown face down. Participants were instructed to turn over the top card within the deck and to examine the body image printed upon it. They were then asked to place this card face down onto the printed PFRS scale at a location corresponding to BMI depicted in the PFRS. This procedure was repeated until all fifteen body cards had been placed face down. At the completion of this procedure each of our rendered female body stimulus cards were ascribed a score based on their hypothetical position on the PFRS scale. For instance, if our thinnest rendered body image (ascribed "1") was placed against the second-to leftmost body of the PFRS (category "2"), this received a difference score of 1. If the first body of the novel FRS was placed against the fourth category image of the PFRS, this received a difference score of 3. Scores each of our computer-generated body images were then averaged across participants. If the average difference score for a given rendered body image was less or greater than ±1 of a given PFRS subcategory, the stimuli were either discarded or remodeled and re-rendered until a complete set of rendered images were produced corresponding to each of the ten photographs shown in the PFRS. The second pilot study was run to confirm that the adjusted images more closely corresponded with the discrete visual body categories constituting the PFRS. These ten images were used in the main Figure Rating Scale experiment (**Figure 2**).

Administration of the FRS

The 10 rendered bodies selected for our FRS were presented on a computer screen as shown in **Figure 2**. Participants were asked to select the body most closely resembling their own body followed by the body most closely corresponding to their ideal body. Subjects registered their responses by typing the letter located beneath their selected body image on a computer keyboard. The overall FRS score was calculated by subtracting the number (where $a = 1$, $b = 2$, etc.) paired with the perceived ideal body from the number paired with the body representing the participant's own body. The absolute value of this difference score was taken as an index of body dissatisfaction (Talbot et al., 2018a,b).

Eating Disorder Examination – Questionnaire

The Eating Disorder Examination Questionnaire (EDE-Q) (Fairburn and Beglin, 1994) was used to measure eating disorder symptomology for all participants. The EDE-Q is an adaptation of the Eating Disorder Examination, considered to be the gold standard for assessing the core features of anorexia nervosa, bulimia nervosa, and eating disorders not otherwise specified (Guest, 2000). The EDE-Q is widely used and has been shown to be a valid and reliable measure of eating disorders symptomology (Luce and Crowther, 1999; Grilo et al., 2001; Mond et al., 2004; Reas et al., 2006; Berg et al., 2012). It includes descriptive information regarding eating disorder psychopathology and is designed to assess specific behavioral symptoms such as excessive exercise, binge eating, diuretic misuse, laxative misuse and self-induced vomiting. It includes 28 questions, including 7-point, forced-choice rating schemes measured in terms of the number of days on which particular behaviors or attitudes occur. Participants receive a Global score, and a score for each of the four subscales relating to cognitive features of eating disorders. The four subscales include Restraint, Eating Concern, Shape Concern, Weight Concern.

Body Shape Questionnaire-34

The female-version of the Body Shape Questionnaire – 34 (Cooper et al., 1987) was administered to all participants. This is a self-report measure that assesses the levels of body dissatisfaction experienced during the past 4 weeks (28 days). This measure is the most commonly used measure in the literature on attentional bias and body dissatisfaction. Questions assess satisfaction and level of concern toward shape and weight, e.g., "Has being with thin women made you feel self-conscious about your shape?" and "Have you been so worried about your shape that you have been feeling you ought to diet?." Participants are asked to rate how often they have experienced body/shape/weight related concerns from never to always. Participants receive a Global score of general body dissatisfaction, ranging from 34 to 206, with higher scores indicating higher levels of body dissatisfaction. The BSQ has been shown to be a valid and reliable measure of body dissatisfaction in women, $\alpha = 0.98$ (Cooper et al., 1987; Varnado-Sullivan et al., 2006).

Body Mass Index

Body mass index was calculated for each participant by recording their body mass (in kg) and dividing it by the square of the height (cm) and expressed in units of kg/m^2.

Visual Search Task

The visual search task was programed in MATLAB using the Psychtoolbox extensions (Brainard, 1997; Pelli, 1997;

Kleiner et al., 2007). The stimulus was presented using a COMPAQ S920 cathode ray tube computer monitor. Screen resolution was set to 1024 × 768 pixels with a refresh rate of 85 Hz. Viewing distance was fixed at 340 mm. All images appeared against a background set to mid gray. At the beginning of each trial a gray fixation cross superimposed upon a white circle appeared at the center of the screen (see **Figure 1**). Then, 500 ms later, a primary stimulus and a secondary stimulus appeared. The primary stimulus was a single horizontal or vertical blue *target* line embedded with an array of nine oblique blue distractor lines (±10 degrees from vertical or horizontal). All lines were 0.7 mm in length, 1 mm in width. The line stimuli were regularly spaced on an invisible circle (radius = 13.5 cm) centered on the fixation cross. The location of the target line varied randomly from trial to trial so that the participant was unable to reliably predict its location.

Each primary target and distractor line stimulus was paired with a single female body image (the secondary stimulus). On average, each body image was 0.6 cm in height (top of "head" to soles of feet) and 0.3 cm in width (left to right finger tips). Each of these ten secondary body stimuli were positioned on a smaller invisible circle (radius = 9.5 cm) centered on the fixation cross. The center of each body image was located at the same polar angle (origin = fixation cross) as the center of its nearest primary line stimulus.

Across conditions, three different rendered bodies were presented: underweight-deviant body, a neutral body, and a with overweight body, representing three BMI categories: underweight (<18.5 kg/m^2); normal (18.5–24.9 kg/m^2); and obese (>30 kg/m^2), respectively. This stimulus was a subset of images, rendered for the Figure Rating Scale. Again, these bodies were rendered with black underwear and their heads occluded by a black ellipse. For *congruent* trials, all bodies on the screen were identical average weight bodies, but for one deviant body (either underweight-deviant or with-overweight-deviant), which was paired with the target line. For *incongruent* trials, all bodies on the screen were identical average weight bodies but for one deviant body (either underweight-deviant or with overweight-deviant), which was paired with one of the distractor lines. For *neutral* trials, all bodies on the screen were identical average weight bodies with no underweight-deviant or overweight-deviant bodies presented. Examples of the main experimental conditions are depicted in **Figure 1**. Each participant was presented with 420 trials in total, including 224 congruent trials, 84 neutral trials and 112 incongruent trials. In half of the congruent and incongruent trials, an underweight-deviant body was displayed, and in the other half a with overweight-deviant body was displayed. There were more congruent trials than incongruent and neutral trials to encourage participants to use body shape as a cue to guide their search for the target line. Participants completed the task in two parts (210 trials each).

On each trial participants were instructed to identify the orientation of the target line as quickly and accurately as possible, using the left shift key for horizontal and the right shift key for vertical targets. Once the participant made a response, the primary and secondary stimulus disappeared, and the fixation point remained on the screen for 2 s between trials, to allow participants to center their gaze. The accuracy and speed with which participants were able to identify the orientation of the single unique target line was recorded.

Procedure

Each participant was tested individually for approximately 1 h. After completion of the written consent form, participants completed (i) a demographic survey, (ii) the FRS, (iii) EDE-Q, and (iv) BSQ. These surveys and scales were all programed using Qualtrics software and administered via a desktop computer monitor and keyboard. Participants' height and weight were recorded for BMI calculations. They were then seated in front of the computer screen at a viewing distance of 50 cm and received verbal instructions on the compound visual search task. Following this instruction each participant was presented with 15 practice trials. At the completion of the practice session, participants were able to ask questions if further clarity was required. Participants completed the subsequent visual search task in two blocks (approximately 18 min per block) with a 1–2 min break between each block.

RESULTS

Reaction time (RT) data from 71 participants were screened for accuracy, missing data, univariate and multivariate outliers. Data screening revealed no missing data and all recorded values were within a range appropriate to the variable scales. RTs for incorrect visual search trials (1358 trials) were omitted from the analyses (e.g., answered horizontal, when target was vertical, or vice versa). Additionally, RTs greater than 4000 ms were omitted from subsequent analysis to preclude task-irrelevant behavior, such as looking away from the screen, yielding on average 28.4% of trials per participant (S.E. = 1.3%) being omitted from subsequent analysis. Correct line judgments were then averaged across trial type, including (i) underweight-deviant congruent trials, (ii) with-overweight-deviant congruent trials, (iii) neutral trials, (iv) underweight-deviant incongruent trials, and (v) with-overweight-deviant congruent trials. BMI ranged from 16.21 to 46.29 (M = 26.21, SD = 6.33). BSQ ranged from 48 to 188 (M = 108.20, SD = 35.51). The average EDE-Q Global Score was 2.43 (SD = 1.45), which comprised the average of the four subscales, including, Restraint (M = 2.07, SD = 1.61), Eating Concern (M = 1.59, SD = 1.53), Shape Concern (M = 3.23, SD = 1.77), and Weight Concern (M = 2.81, SD = 1.58). Scores on the FRS, ranged from −8 to 6 (M = 2, SD = 2.07).

Visual Search Effects

The RTs for the congruent and incongruent trials for all participants across the three body size conditions (underweight, neutral and with-overweight), were analyzed using a 2 × 3 repeated measures analysis of variance (ANOVA). ANOVA test assumptions were satisfactory with the exception of Mauchly's test of sphericity, which indicated that the sphericity assumption was not met for body type $\chi^2(2) = 40.70$, $p < 0.001$. Therefore, degrees of freedom were corrected for body type using the Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.692$). The main effect for congruency was significant, $F(1, 70) = 27.51$, $p < 0.001$. Means for congruent and incongruent trials were 2549 ms and 2721, respectively. The main effect for body size was also significant with a Greenhouse-Geisser adjustment to the degrees of freedom, $F(1.38, 96.85) = 18.250$, $p < 0.001$. Means for underweight body types, neutral body types and with overweight body types were 2593 ms, 2741 ms and 2559 ms, respectively. The congruency by body type trials interaction was significant with a Huynh-Feldt adjustment applied to the degrees of freedom ($\varepsilon = 0.805$), $F(1.64, 114.92) = 21.07$, $p < 0.001$ (see **Figure 3A**).

To deconstruct this interaction, five pairwise comparisons were conducted, using a Bonferroni adjusted alpha of 0.01 to adjust for family wise error. For congruent trials, average search times involving underweight-deviant bodies, $t(70) = 5.02$, $p < 0.001$, and those involving with-overweight-deviant bodies, $t(70) = 5.24$, $p < 0.001$, were both significantly faster than neutral trials in which no deviant underweight or with-overweight body was presented. Whilst a trend emerged indicating that for congruent trials, search times involving with-overweight-deviant bodies were often faster than those involving underweight-deviant bodies, this difference did not survive Bonferroni-adjustment, $t(70) = 2.42$, $p = 0.09$. For incongruent trials, there were no significant differences in average search times in the presence of either a with-overweight body, $t(70) = -1.17$, $p = 0.245$, or an underweight body, $t(70) = -1.02$, $p = 0.313$, when compared to neutral trials.

Correlation Analyses

Scatterplots were examined to ensure linear and homoscedastic assumptions were met allowing for bivariate correlational analysis. Additionally, the scatterplots were screened for outliers. Upon inspection of the scatterplots of the correlation between the FRS and difference scores, one participant was identified as a significant outlier with a FRS score of −8. This outlier was removed from all subsequent analyses. Spearman product-moment correlations were performed between each measure of body dissatisfaction (BSQ, EDE-Q Global and subscales, FRS), BMI, and various visual search performance (RT) comparisons.

Significant linear correlations were found between the standard measures of body dissatisfaction (BSQ-34 and EDE-Q) and BMI (all p-values < 0.001). Our novel measure of body dissatisfaction, the FRS, correlated significantly with all other measures of body dissatisfaction as well as the BMI (all p-values < 0.001).

In order to examine linear associations between visual search performance (RTs) and our various psychological and physiological measures, a series of Spearman's correlation analyses were conducted. Of the analyses involving raw average reaction times for each of *congruent*, *incongruent*, and *neutral* search conditions only one significant correlation was observed: a marginal positive linear association between neutral search times and BMI, $r_s = 0.236$, $p = 0.049$. This suggests that for neutral trials, subjects with higher BMIs tended to take longer to complete the search task than do subjects with lower BMIs. This relationship, however, did not survive Bonferroni adjustment.

Additional correlational analyses were conducted based on a selection of RT difference scores. The first of these involved a measure of congruent underweight vs with-overweight search bias. This was calculated by subtracting *congruent with-overweight* search times from *congruent underweight* search times such that a positive value implies an overweight search bias, and a negative value, an underweight search bias. A significant correlation was observed between this measure of search bias and BMI, $r_s = 0.325$, $p = 0.006$ (Bonferroni adjusted $p = 0.048$). Visual analysis of **Figure 3B** suggests that this positive association is principally driven by the predominantly with-overweight search biases exhibited by participants with BMIs > 25 kg/m^2.

A full list of all correlational analyses performed can be found in **Supplementary Table S1**. To determine whether this with-overweight search bias was in fact driven principally driven by sensitivity to the with-overweight bodies, second of these RT difference score correlations involved a measure of with-overweight search bias that was not contingent upon performance in underweight conditions. This was calculated by subtracting *congruent with-overweight* search times from search times obtained in the *neutral* body condition, such that positive values imply that congruent trials containing with-overweight bodies produced faster search performance on average than neutral trials (with-overweight search bias), and negative values imply that overweight bodies slowed search relative to neutral trials (with-overweight search anti-bias). These difference scores exhibited a significant (non-adjusted) positive association with BMI, $r_s = 0.290$, $p = 0.015$ (**Figure 3C**), indicating that higher BMI individuals tend to search for with-overweight targets more rapidly than they do on neutral trials, relative to lower BMI individuals.

Whilst significant correlations were observed between our measures of body dissatisfaction and (absolute or relative) search times. One interesting exception did emerge, however, in the relationship between EDE-Q Restraint and the difference in congruent search times involving underweight bodies compared to neutral conditions. This relative search variable is calculated by subtracting search times derived from neutral trials from those observed on congruent trials involving underweight bodies. According to this calculation, negative values correspond to faster search in trials involving underweight bodies, indicating an Underweight search bias, with positive values indicating an Underweight search anti-bias. Although there was no overall significant linear relationship between EDE-Q Restraint and neutral minus congruent underweight search times (red dashed line in **Figure 3D**), a highly significant linear relationship was evident once a critical level of underweight search bias was reached (±250 ms; red dotted line in **Figure 3D**). The effect of variation in this underweight bias cut-off on the linear association between EDE-Q Restraint and the magnitude of observed underweight search biases is shown in **Figure 3E**. In this figure, the strength of obtained Spearman's rho correlations (y-axis) are expressed as a function various [underweight – neutral]

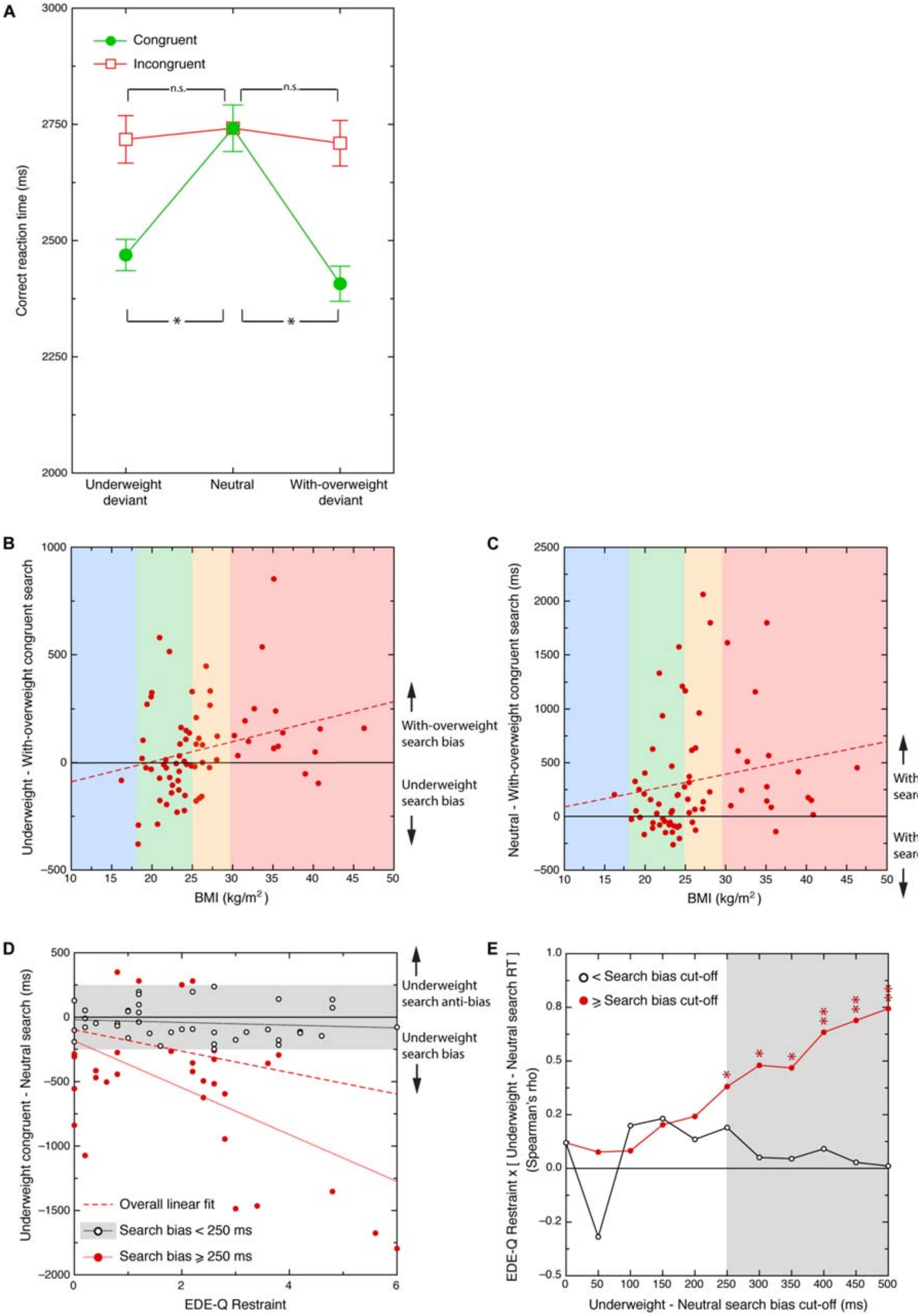

FIGURE 3 | Continued

FIGURE 3 | (A) Search times averaged across participants (*y*-axis) to congruent and incongruent trials (green circles and red squares, respectively) across the three body type conditions. Error bars are between-subject standard errors. Asterisks represent significant differences between both congruent deviant image conditions and the neutral (deviant absent) condition ($p < 0.01$). **(B)** Scatterplot showing the relationship between participant BMI and the difference in reaction time to underweight-deviant and with-overweight-deviant bodies on congruent trials. A positive difference score (*y*-axis) indicates faster search times to with-overweight relative to underweight body images (with-overweight search bias) and a negative difference score faster search to underweight relative to with-overweight body images (underweight search bias). The dashed line is the best fitting linear correlation. Vertically arranged colors represent conventional BMI categories. Unbroken horizontal line indicates zero bias. **(C)** Scatterplot of the relationship between participant BMI and the difference in reaction time on neutral and with-overweight-deviant congruent trials. Positive difference scores (*y*-axis) signify faster search times to with-overweight relative to neutral body images (with-overweight search bias). Negative difference scores indicate faster search to neutral relative to with-overweight body images (with-overweight search anti-bias). The dashed line is the best fitting linear correlation. Vertically arranged colors represent conventional BMI categories. Unbroken horizontal line indicates zero bias. **(D)** Scatterplot showing the relationship between EDE-Q Restraint and the difference in reaction time to underweight-congruent trials and neutral trials. A negative difference score indicates faster search to underweight relative to neutral body images (underweight bias) and a positive score, faster search to neutral relative to underweight body images (underweight anti-bias). Red dashed line is the overall best fitting linear correlation. White circles depict participants who produce weak ($< \pm 250$ ms) underweight search bias (within gray region), and red circles, participants with strong underweight search biases ($\geq \pm 250$ ms). Black and red dotted lines represent linear correlations between for these weak and strong search biased groups, respectively. Unbroken horizontal line indicates zero bias. **(E)** EDE-Q Restraint × [underweight – neutral] search time correlations across different levels of underweight-neutral search bias. Red circles/red line show participants with underweight search biases equal to above the variable bias cut-off, white circles/black line show participants with underweight search biases beneath the variable bias cut-off. Asterisks represent statistically significant Spearman's rho values (*$p < 0.05$; **$p < 0.01$). Gray region signifies underweight search bias, beyond which significant correlations with EDE-Q Restraint (±250 ms) are observed. Note, the Spearman's rho value (*y*-axis) associated with a cut-off score of zero (*x*-axis) is equivalent to that of the red dashed linear fit in **Figure 3D**. Unbroken horizontal line indicates zero correlation.

bias cut-off values (*x*-axis). The figure shows significant linear dependencies between EDE-Q Restraint and underweight minus neutral search times for participants who produce (strong) underweight trial search biases of at least ±250 ms (red symbols) $r_s = 0.381$, $p = 0.016$. Applying Bonferroni adjustments indexed by the number of underweight bias cut-offs compared in this analysis (11), reveals linear associations for underweight search biases of at least 400 ms ($r_s = 0.634$, $p = 0.022$). By contrast, no linear association is observed for participants who produce (weak) underweight search biases, i.e., lower than any of the cut-offs tested (white circles).

DISCUSSION

This is the first study to systematically examine attentional bias to female body stimuli using a compound visual search paradigm. As hypothesized, results indicate that overall, participants performed the visual search task more rapidly when target lines were paired with a single underweight or with-overweight body image compared to neutral trials, which contained only average weight bodies. This demonstrates that variations in the visual representation of body fat (and lack thereof) can be used to guide visual search. Contrary to predictions, there were no significant differences in search latencies for incongruent trials relative to neutral trials. That pairing a uniquely underweight or with-overweight body image with a distractor line failed to produce significant search costs implies that the depicted variations in female body fat did not compulsorily capture our participants' visual attention (Wolfe and Horowitz, 2004).

Contrary to our predictions, we found no evidence that high BMI is associated with faster search to underweight, idealized bodies relative to neutral (average weight only) body conditions. We did, however, observe a positive linear association between BMI and search times for underweight relative to with-overweight-congruent search conditions. Visual inspection of the scatterplot between these variables (**Figure 3B**) indicates that this association is predominantly driven by a with-overweight search bias combined with an almost complete absence of any thin search biases expressed by participants in the with-overweight BMI range (red region). By contrast, participants in the normal BMI range (green region) expressed a broad range of both underweight and with-overweight search biases. A similar trend is evident in **Figure 3C**, showing that most participants in higher BMI ranges express a with-overweight search bias relative to neutral conditions.

Both of these results imply that our higher range BMI participants tend to exhibit attentional biases favoring visual representations of human body mass that more closely resemble their own bodies. Whilst this might reflect the operation of complex social comparison processes, a more parsimonious explanation is that visual information that individuals are more familiar with tends to be processed more efficiently (and searched for more rapidly) than less familiar visual information (Qin et al., 2014). Assuming that our subjects are most visually familiar with their own bodies – as seen in the mirror, for example – it follows that body images more closely resembling our participants' own bodies should elicit faster search than body images which are more dissimilar. Why this systematic visual search bias should be restricted to higher range BMI individuals is unknown. Given the diverse search biases expressed between individuals within the normal BMI range, it is conceivable that those in this range may be influenced by a more diverse set of factors, possibly involving historical experiences with one's own body or the bodies of others.

On the face of it this tendency for our high BMI participants to exhibit an almost universal search bias favoring with-overweight bodies appears broadly inconsistent with a recent eye-movement study (Warschburger et al., 2015) showing that with-overweight individuals tend to produce more numerous and longer fixations to "more attractive" body regions than normal weight individuals. Given that with-overweight bodies tend to be rated as less attractive than normal weight bodies, if attractiveness were the sole determinant of attentional bias, based on the findings of Warschburger et al. (2015) we might expect with-overweight individuals to exhibit an underweight rather than a with-overweight search bias. Our results find the opposite relationship. It is worth noting that the line drawing body images used by Warschburger et al. (2015) did not vary in terms of their representation of body weight. Future research investigating the relative attractiveness of different body regions across different body shapes (e.g., underweight through to with-overweight) on both search and eye-movement behavior is necessary to determine what body-related factors drive attentional behavior in females.

The absence of any overall linear associations between visual search performance, the BSQ, EDE-Q and the FRS suggests that these psychological measures are not systematically related to our visual search task. A more nuanced analysis, however, reveals an interesting relationship between the EDE-Q Restraint subscale and the difference in search times on *congruent underweight* relative to *neutral* trials. By distinguishing between weakly and more strongly underweight search-biased subjects (ambivalent to the direction of this bias), we find that individuals who express a stronger search bias ($\geq \pm 250$ ms) exhibit a strong linear dependency between eating restraint and more rapid search for underweight relative to neutral bodies, with those scoring high on EDE-Q Restraint tending to benefit more from the presence of congruent underweight bodies than those low on EDE-Q Restraint. This suggests an attentional bias favoring underweight body types for individuals high in eating restraint. By contrast, those exhibiting a weak search bias did not show any such dependency. This dissociation between the strength (but not necessarily the direction) of underweight search bias suggests the existence of two sub-types in our population of female participants: (i) those whose attitudes toward eating behavior (restraint, in this case) are linked to their propensity to search for underweight relative to neutral bodies; and (ii) those whose attitudes toward eating are unrelated to their search behavior.

Whilst correlated to the other measures of body dissatisfaction, the eating restraint subscale of the EDE-Q is a behavioral manifestation of body image disturbance in that it centers on an individual's desire to influence their weight and shape through certain active behaviors. Questions for this subscale center on strict dietary rules, limiting food intake, excluding foods from diet, desire for an empty stomach and restraining from eating for long periods of time. Restraint assesses specific behavioral symptoms that are active and goal-directed toward altering personal weight and shape (Penelo et al., 2013). A possible explanation for the attentional bias toward underweight bodies with high eating restraint (amongst search biased individuals) is that these individuals may engage in automatic upward social comparison processes (Rancourt et al., 2016). For instance, individuals high in restraint may look to thinner, ideal body types to gain information for self-improvement and to achieve their own body-image goals. Alternatively, this attentional bias may reflect a strategy which reinforces one's goal-directed weight-restricted ideals and behaviors.

As expected, we observed strong positive correlations between participant BMI, and the various measures of body dissatisfaction and eating disorders (Hudson et al., 2007; Ro et al., 2012). Results also showed strong significant positive correlations between the FRS, and self-report measures of body shape dissatisfaction, eating disorder symptoms, and BMI. This suggests that our version of the FRS is a valid indicator of psychological and physiological variables related to body dissatisfaction. Given that figural rating scales offer numerous advantages over traditional self-report measures of body dissatisfaction (e.g., faster administration times, reduce interpretation biases, and non-reliant on language proficiency; Grogan, 2016), future research should seek to provide additional validity and test–retest reliability evidence for the FRS developed in the present study.

In terms of previous literature on the relationship between attentional bias to body shape and female body dissatisfaction the question remains as to how our results relate to the numerous and highly variable results derived from dot-probe, Stroop and eye-movement paradigms.

According to Jiang and Vartanian (2012), Stroop studies generally show greater interference for "fat-related" words such as "chubby" or "stomach" than for neutral words, particularly amongst restrained eaters. This general finding appears contrary to our findings which failed to observe any systematic relationship between eating restraint and attentional bias to with-overweight bodies. The strong linear correlation that we observe between eating restraint and search performance favoring underweight bodies (relative to average body weight conditions) suggests that eating restraint is better predicted by attentional bias to underweight than it is by attentional bias to with-overweight bodies. To our knowledge, no studies have compared the effects of thin- and fat-related words using a Stroop paradigm in a non-clinical population.

Studies that have sought to investigate the relationship between attentional bias to visual body weight information and body dissatisfaction using the more conventional dot-probe paradigm have reported a broad set of effects, ranging from no relationship with eating restraint (Boon et al., 2000; Smith and Rieger, 2010) to demonstration of a bias toward fat-related information and away from thin-related information in participants with eating disorders (Rieger et al., 1998; Shafran et al., 2007). Our observed relationship between restraint and attentional search biases favoring underweight bodies contradicts these findings. Why our paradigm should yield a different set of dependencies to those observed in the dot-probe paradigm remains an open question.

One possibility may lie in differences in volitional control. Whereas the dot probe involves very brief exposure durations (100–500 ms) and yields relatively short reaction times (typically 400–600 ms), the line and body stimuli used in our search task remained on the screen until the participant made a response, yielding much longer response times on average (∼2500–2700 ms). Both of these factors suggest that the attentional strategies participants use to perform each task may be very different. Whereas the dot-probe performance is likely to be informed by response strategies devoted to the appearance of dot-probe target elements which are not reliably linked a particular body type, in the case of our compound search task target line identification performance is likely to benefit from a more volitional analysis of the body image content (in congruent conditions, at least). Whilst it is tempting, therefore, to suggest that the different patterns of attentional bias observed in dot-probe and our compound search paradigm may reflect the operation of distinct strategic and/or attentional processes, the validity of this interpretation rests on future studies to compare the relative effects of different body types in each paradigm using identical sets of body stimuli.

Regarding our search stimuli, all body images used in our study were shown in identical poses from a single viewing perspective (frontoparallel plane) and all bodies had Caucasian skin tones. Both the viewpoint and surface characteristics of objects has been found to profoundly influence both brain responses and recognition performance across a variety of stimulus classes – including bodies (Chan et al., 2004; Favelle et al., 2011; Reppa et al., 2015). Ethnicity-linked visual cues have been found to differentially affect search behavior depending upon one's own ethnicity (Zhou et al., 2015). Future research is required to determine the relative contribution of these various socio-cultural and imaged-based factors to both attentional biases to body weight information and body dissatisfaction.

With respect to our participants, given that pressures to meet certain body ideals are likely to differ greatly between age groups (Paxton et al., 1999; Wasylkiw and Williamson, 2013) it would be useful to examine a more broadly aged sample to better understand relationships between body ideals and attentional bias. Additionally, our study neglected muscularity – a facet of body image that is becoming increasingly important to women (Bozsik et al., 2018; Rodgers et al., 2018). Future studies should seek to examine the relationship between attention and female bodies that vary in terms of muscular tone and size. Another important factor to consider in future studies is the role of sex. Male body dissatisfaction, dysmorphia and disordered eating are prevalent yet relatively understudied (Cohane and Pope, 2001; Adams et al., 2005; Griffiths et al., 2014, 2018; Grogan, 2016). Although recent progress has been made (Griffiths et al., 2014; Smith et al., 2017; Talbot et al., 2018b) few studies have investigated the relationship between attentional bias and body dissatisfaction in the male population. A recent exception to this is a study by Talbot et al. (2019) which employed a similar compound search paradigm to that used here, but with male participants and images of male bodies. Interestingly, unlike the current study they found that measures of body dissatisfaction were associated with search performance involving images of with-overweight bodies. Why body dissatisfaction should be linked to search performance involving images of underweight bodies in females and images of with-overweight bodies in males is unknown, although it may point to strategic differences in the way females and males relate to body-weight related visual information.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

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

AUTHOR CONTRIBUTIONS

JC designed the study, analyzed the data, and wrote the manuscript. GG ran the experiment, analyzed the data, and wrote the manuscript. DT wrote the manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02821/full#supplementary-material

TABLE S1 | Spearman correlations and associated uncorrected *p*-values between BMI and measures of body dissatisfaction.

REFERENCES

Adams, G., Turner, H., and Bucks, R. (2005). The experience of body dissatisfaction in men. *Body Image* 2, 271–283. doi: 10.1016/j.bodyim.2005.05.004

Berg, K. C., Peterson, C. B., Frazier, P., and Crow, S. J. (2012). Psychometric evaluation of the eating disorder examination and eating disorder examination-questionnaire: a systematic review of the literature. *Int. J. Eat. Disord.* 45, 428–438. doi: 10.1002/eat.20931

Boon, B., Vogelzang, L., and Jansen, A. (2000). Do restrained eaters show attention toward or away from food, shape and weight stimuli? *Eur. Eat. Disord. Rev.* 8, 51–58. doi: 10.1002/(SICI)1099-0968(200002)8:1<51::AID-ERV306>3.0.CO;2-E

Bozsik, F., Whisenhunt, B. L., Hudson, D. L., Bennett, B., and Lundgren, J. D. (2018). Thin is in? Think again: the rising importance of muscularity in the thin ideal female body. *Sex Roles* 79, 609–615. doi: 10.1007/s11199-017-0886-0

Brainard, D. H. (1997). The psychophysics toolbox. *Spat. Vis.* 10, 433–436. doi: 10.1163/156856897x00357

Chan, A. W., Peelen, M. V., and Downing, P. E. (2004). The effect of viewpoint on body representation in the extrastriate body area. *Neuroreport* 15, 2407–2410. doi: 10.1097/00001756-200410250-00021

Cho, A., and Lee, J. H. (2013). Body dissatisfaction levels and gender differences in attentional biases toward idealized bodies. *Body Image* 10, 95–102. doi: 10.1016/j.bodyim.2012.09.005

Cohane, G. H., and Pope, H. G. Jr. (2001). Body image in boys: a review of the literature. *Int. J. Eat. Disord.* 29, 373–379. doi: 10.1002/eat.1033

Cooper, M. J., Anastasiades, P., and Fairburn, C. G. (1992). Selective processing of eating-, shape-, and weight-related words in persons with bulimia nervosa. *J. Abnorm. Psychol.* 101, 352–355. doi: 10.1037//0021-843x.101.2.352

Cooper, P. J., Taylor, M. J., Cooper, Z., and Fairbum, C. G. (1987). The development and validation of the body shape questionnaire. *Int. J. Eat. Disord.* 6, 485–494. doi: 10.1002/1098-108x(198707)6:4<485::aid-eat2260060405>3.0.co;2-o

Crossley, K. L., Cornelissen, P. L., and Tovee, M. J. (2012). What is an attractive body? Using an interactive 3D program to create the ideal body for you and your partner. *PLoS One* 7:e50601. doi: 10.1371/journal.pone.0050601

Davidson, E. J., and Wright, P. (2002). Selective processing of weight- and shape-related words in bulimia nervosa: use of a computerised Stroop test. *Eat. Behav.* 3, 261–273. doi: 10.1016/s1471-0153(02)00064-8

Downing, P. E., Jiang, Y., Shuman, M., and Kanwisher, N. (2001). A cortical area selective for visual processing of the human body. *Science* 293, 2470–2473. doi: 10.1126/science.1063414

Fairburn, C. G., and Beglin, S. J. (1994). Assessment of eating disorders: interview or self-report questionnaire? *Int. J. Eat. Disord.* 16, 363–370.

Faunce, G. J. (2002). Eating disorders and attentional bias: a review. *Eat. Disord.* 10, 125–139. doi: 10.1080/10640260290081696

Favelle, S. K., Palmisano, S., and Avery, G. (2011). Face viewpoint effects about three axes: the role of configural and featural processing. *Perception* 40, 761–784. doi: 10.1068/p6878

Fiske, L., Fallon, E. A., Blissmer, B., and Redding, C. A. (2014). Prevalence of body dissatisfaction among United States adults: review and recommendations for future research. *Eat. Behav.* 15, 357–365. doi: 10.1016/j.eatbeh.2014.04.010

Gao, X., Deng, X., Yang, J., Liang, S., Liu, J., and Chen, H. (2014). Eyes on the bodies: an eye tracking study on deployment of visual attention among females with body dissatisfaction. *Eat. Behav.* 15, 540–549. doi: 10.1016/j.eatbeh.2014.08.001

Gao, X., Li, X., Yang, X., Wang, Y., Jackson, T., and Chen, H. (2013). I can't stop looking at them: interactive effects of body mass index and weight dissatisfaction on attention towards body shape photographs. *Body Image* 10, 191–199. doi: 10.1016/j.bodyim.2012.12.005

Gardner, R. M., Jappe, L. M., and Gardner, L. (2009). Development and validation of a new figural drawing scale for body-image assessment: the BIAS-BD. *J. Clin. Psychol.* 65, 113–122. doi: 10.1002/jclp.20526

Glauert, R., Rhodes, G., Fink, B., and Grammer, K. (2010). Body dissatisfaction and attentional bias to thin bodies. *Int. J. Eat. Disord.* 43, 42–49. doi: 10.1002/eat.20663

Griffiths, S., Angus, D., Murray, S. B., and Touyz, S. (2014). Unique associations between young adult men's emotional functioning and their body dissatisfaction and disordered eating. *Body Image* 11, 175–178. doi: 10.1016/j.bodyim.2013.12.002

Griffiths, S., Brennan, L., O'Gorman, B., Goedel, W. C., Sheffield, J., Bastian, B., et al. (2018). Experiences of weightism among sexual minority men: relationships with body mass index, body dissatisfaction, and psychological quality of life. *Soc. Sci. Med.* 214, 35–40. doi: 10.1016/j.socscimed.2018.08.018

Grilo, C. M., Masheb, R. M., and Wilson, G. T. (2001). A comparison of different methods for assessing the features of eating disorders in patients with binge eating disorder. *J. Consult. Clin. Psychol.* 69, 317–322. doi: 10.1037//0022-006x.69.2.317

Grogan, C. (2016). *Body Image: Understanding Body Dissatisfaction in Men, Women and Children*. Abingdon: Taylor & Francis.

Guest, T. (2000). Using the eating disorder examination in the assessment of bulimia and anorexia: issues of. (reliability)and validity. *Soc. Work Health Care* 31, 71–83. doi: 10.1300/j010v31n04_05

Hildebrandt, T., Langenbucher, J. W., Lai, J. K., Loeb, K. L., and Hollander, E. (2011). Development and validation of the appearance and performance enhancing drug use schedule. *Addict. Behav.* 36, 949–958. doi: 10.1016/j.addbeh.2011.05.002

Hudson, J. I., Hiripi, E., Pope, H. G. Jr., and Kessler, R. C. (2007). The prevalence and correlates of eating disorders in the National Comorbidity Survey Replication. *Biol. Psychiatry* 61, 348–358. doi: 10.1016/j.biopsych.2006.03.040

Jiang, M. Y., and Vartanian, L. R. (2012). Attention and memory biases toward body-related images among restrained eaters. *Body Image* 9, 503–509. doi: 10.1016/j.bodyim.2012.06.007

Jiang, M. Y., and Vartanian, L. R. (2018). A review of existing measures of attentional biases in body image and eating disorders research. *Aust. J. Psychol.* 70, 2–17.

Joseph, C., LoBue, V., Rivera, L. M., Irving, J., Savoy, S., and Shiffrar, M. (2016). An attentional bias for thin bodies and its relation to body dissatisfaction. *Body Image* 19, 216–223. doi: 10.1016/j.bodyim.2016.10.006

Kanayama, G., Pope, H. G. Jr., and Hudson, J. I. (2001). "Body image" drugs: a growing psychosomatic problem. *Psychother. Psychosom.* 70, 61–65. doi: 10.1159/000056228

Keel, P. K., and Klump, K. L. (2003). Are eating disorders culture-bound syndromes? Implications for conceptualizing their etiology. *Psychol. Bull.* 129, 747–769. doi: 10.1037/0033-2909.129.5.747

Kleiner, M., Brainard, D., Pelli, D., Ingling, A., Murray, R., and Broussard, C. (2007). What's new in Psychtoolbox-3. *Perception* 36, 1–16.

Luce, K. H., and Crowther, J. H. (1999). The reliability of the eating disorder examination-self-report questionnaire version (EDE-Q). *Int. J. Eat. Disord.* 25, 349–351. doi: 10.1002/(sici)1098-108x(199904)25:3<349::aid-eat15>3.3.co;2-d

Mond, J., Mitchison, D., Latner, J., Hay, P., Owen, C., and Rodgers, B. (2013). Quality of life impairment associated with body dissatisfaction in a general population sample of women. *BMC Public Health* 13:920. doi: 10.1186/1471-2458-13-920

Mond, J. M., Hay, P. J., Rodgers, B., Owen, C., and Beumont, P. J. (2004). Validity of the eating disorder examination questionnaire (EDE-Q) in screening for eating disorders in community samples. *Behav. Res. Ther.* 42, 551–567. doi: 10.1016/S0005-7967(03)00161-X

Most, S. B., Smith, S. D., Cooter, A. B., Levy, B. N., and Zald, D. H. (2007). The naked truth: positive, arousing distractors impair rapid target perception. *Cogn. Emot.* 21, 964–981. doi: 10.1080/02699930600959340

Park, H., Abellanoza, C., Schaeffer, J., and Gandy, K. (2014). Source recognition by stimulus content in the MTL. *Brain Res.* 1553, 59–68. doi: 10.1016/j.brainres.2014.01.029

Paxton, S. J., Schutz, H. K., Wertheim, E. H., and Muir, S. L. (1999). Friendship clique and peer influences on body image concerns, dietary restraint, extreme weight-loss behaviors, and binge eating in adolescent girls. *J. Abnorm. Psychol.* 108, 255–266. doi: 10.1037//0021-843x.108.2.255

Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: transforming numbers into movies. *Spat. Vis.* 10, 437–442. doi: 10.1163/156856897x00366

Penelo, E., Negrete, A., Portell, M., and Raich, R. M. (2013). Psychometric properties of the eating disorder examination questionnaire (EDE-Q) and norms for rural and urban adolescent males and females in Mexico. *PLoS One* 8:e83245. doi: 10.1371/journal.pone.0083245

Perpina, C., Hemsley, D., Treasure, J., and de Silva, P. (1993). Is the selective information processing of food and body words specific to patients with eating disorders? *Int. J. Eat. Disord.* 14, 359–366. doi: 10.1002/1098-108x(199311)14:3<359::aid-eat2260140314>3.0.co;2-g

Qin, X. A., Koutstaal, W., and Engel, S. A. (2014). The hard-won benefits of familiarity in visual search: naturally familiar brand logos are found faster. *Atten. Percept. Psychophys.* 76, 914–930. doi: 10.3758/s13414-014-0623-5

Rancourt, D., Schaefer, L. M., Bosson, J. K., and Thompson, J. K. (2016). Differential impact of upward and downward comparisons on diverse women's disordered eating behaviors and body image. *Int. J. Eat. Disord.* 49, 519–523. doi: 10.1002/eat.22470

Reas, D. L., Grilo, C. M., and Masheb, R. M. (2006). Reliability of the eating disorder examination-questionnaire in patients with binge eating disorder. *Behav. Res. Ther.* 44, 43–51. doi: 10.1016/j.brat.2005.01.004

Reppa, I., Greville, W. J., and Leek, E. C. (2015). The role of surface-based representations of shape in visual object recognition. *Q. J. Exp. Psychol.* 68, 2351–2369. doi: 10.1080/17470218.2015.1014379

Rieger, E., Schotte, D. E., Touyz, S. W., Beumont, P. J. V., Griffiths, R., and Russell, J. (1998). Attentional biases in eating disorders: a visual probe detection procedure. *Int. J. Eat. Disord.* 23, 199–205. doi: 10.1002/(SICI)1098-108X(199803)23:2<199::AID-EAT10<3.0.CO;2-W

Ro, O., Reas, D. L., and Rosenvinge, J. (2012). The impact of age and BMI on eating disorder examination questionnaire (EDE-Q) scores in a community sample. *Eat. Behav.* 13, 158–161. doi: 10.1016/j.eatbeh.2011.12.001

Rodgers, R. F., Franko, D. L., Lovering, M. E., Luk, S., Pernal, W., and Matsumoto, A. (2018). Development and validation of the female muscularity scale. *Sex Roles* 78, 18–26. doi: 10.1007/s11199-017-0775-6

Sackville, T., Schotte, D. E., Touyz, S. W., Griffiths, R., and Beumont, P. J. (1998). Conscious and preconscious processing of food, body weight and shape, and emotion-related words in women with anorexia nervosa. *Int. J. Eat. Disord.* 23, 77–82. doi: 10.1002/(sici)1098-108x(199801)23:1<77::aid-eat9>3.3.co;2-i

Schmukle, S. C. (2005). Unreliability of the dot probe task. *Eur. J. Pers.* 19, 595–605. doi: 10.1002/per.554

Shafran, R., Lee, M., Cooper, Z., Palmer, R. L., and Fairburn, C. G. (2007). Attentional bias in eating disorders. *Int. J. Eat. Disord.* 40, 369–380. doi: 10.1002/eat.20375

Shinkareva, S. V., Malave, V. L., Mason, R. A., Mitchell, T. M., and Just, M. A. (2011). Commonality of neural representations of words and pictures. *Neuroimage* 54, 2418–2425. doi: 10.1016/j.neuroimage.2010.10.042

Smeets, E., Tiggemann, M., Kemps, E., Mills, J. S., Hollitt, S., Roefs, A., et al. (2011). Body checking induces an attentional bias for body-related cues. *Int. J. Eat. Disord.* 44, 50–57. doi: 10.1002/eat.20776

Smith, E., and Rieger, E. (2010). An investigation of the effect of body dissatisfaction on selective attention toward negative shape and weight-related information. *Int. J. Eat. Disord.* 43, 358–364. doi: 10.1002/eat.20703

Smith, K. E., Mason, T. B., Murray, S. B., Griffiths, S., Leonard, R. C., Wetterneck, C. T., et al. (2017). Male clinical norms and sex differences on the eating disorder inventory (EDI) and eating disorder examination questionnaire (EDE-Q). *Int. J. Eat. Disord.* 50, 769–775. doi: 10.1002/eat.22716

Stice, E., and Shaw, H. E. (2002). Role of body dissatisfaction in the onset and maintenance of eating pathology: a synthesis of research findings. *J. Psychosom. Res.* 53, 985–993. doi: 10.1016/s0022-3999(02)00488-9

Swami, V., Salem, N., Furnham, A., and Tovee, M. J. (2008). The influence of feminist ascription on judgements of women's physical attractiveness. *Body Image* 5, 224–229. doi: 10.1016/j.bodyim.2007.10.003

Swami, V., Stieger, S., Harris, A. S., Nader, I. W., Pietschnig, J., Voracek, M., et al. (2012). Further investigation of the validity and reliability of the photographic figure rating scale for body image assessment. *J. Pers. Assess.* 94, 404–409. doi: 10.1080/00223891.2012.660293

Talbot, D., Cass, J., and Smith, E. (2018a). Visual body scale for men (VBSM): validation of a new figural rating scale to measure actual-ideal body discrepancy in men. *J. Clin. Psychol.* 75, 462–480. doi: 10.1002/jclp.22710

Talbot, D., Smith, E., Cass, J., and Griffiths, S. (2018b). Development and validation of the new somatomorphic matrix–male: a figural rating scale for measuring male actual–ideal body discrepancy. *Psychol. Men Mascul.* 20, 356–367. doi: 10.1037/men0000165

Talbot, D., Smith, E., and Cass, J. (2019). Male body dissatisfaction, eating disorder symptoms, body composition, and attentional bias to body stimuli evaluated using visual search. *J. Exp. Psychopathol.* 10, 1–13.

Taylor, J. C., Wiggett, A. J., and Downing, P. E. (2007). Functional MRI analysis of body and body part representations in the extrastriate and fusiform body areas. *J. Neurophysiol.* 98, 1626–1633. doi: 10.1152/jn.00012.2007

Treisman, A. M., and Gelade, G. (1980). A feature-integration theory of attention. *Cogn. Psychol.* 12, 97–136. doi: 10.1016/0010-0285(80)90005-5

Varnado-Sullivan, P. J., Horton, R., and Savoy, S. (2006). Differences for gender, weight and exercise in body image disturbance and eating disorder symptoms. *Eat. Weight Disord. Stud. Anorexia Bulimia Obes.* 11, 118–125. doi: 10.1007/bf03327556

Walker, M. K., Ben-Tovim, D. I., Paddick, S., and McNamara, J. (1995). Pictorial adaptation of Stroop measures of body-related concerns in eating disorders. *Int. J. Eat. Disord.* 17, 309–311. doi: 10.1002/1098-108x(199504)17:3<309::aid-eat2260170313>3.0.co;2-8

Warschburger, P., Calvano, C., Richter, E. M., and Engbert, R. (2015). Analysis of attentional bias towards attractive and unattractive body regions among overweight males and females: an eye-movement study. *PLoS One* 10:e0140813. doi: 10.1371/journal.pone.0140813

Wasylkiw, L., and Williamson, M. E. (2013). Actual reports and perceptions of body image concerns of young women and their friends. *Sex Roles* 68, 239–251. doi: 10.1007/s11199-012-0227-2

Williamson, D. A., White, M. A., York-Crowe, E., and Stewart, T. M. (2004). Cognitive-behavioral theories of eating disorders. *Behav. Modif.* 28, 711–738. doi: 10.1177/0145445503259853

Wolfe, J. M., and Horowitz, T. S. (2004). What attributes guide the deployment of visual attention and how do they do it? *Nat. Rev. Neurosci.* 5, 495–501. doi: 10.1038/nrn1411

Zhou, G., Cheng, Z., Yue, Z., Tredoux, C., He, J., and Wang, L. (2015). Own-race faces capture attention faster than other-race faces: evidence from response time and the N2pc. *PLoS One* 10:e0127709. doi: 10.1371/journal.pone.0127709

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Fat-Phobic and Non-Fat-Phobic Anorexia Nervosa: A Conjoint Analysis on the Importance of Shape and Weight

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With the introduction of new diagnostic criteria in DSM-5, fear of weight gain no longer represents a sine qua non-criterion for the diagnosis of anorexia nervosa (AN). This is of relevance as a subgroup of individuals with AN denies fear of weight gain as the reason for restrictive eating but still remain at a very low weight. As self-reports are susceptible to bias, other methods are needed to confirm the existence of the subtype in order to provide adapted treatment. Therefore, we aimed to measure fear of weight gain using a novel method in clinical psychology, the conjoint analysis (CA). Relative importance and preference scores for various life aspects, including appearance/shape and weight were assessed in women with fat-phobic AN (FP-AN, n = 30), NFP-AN (n = 7), and healthy controls (n = 29). Individuals with FP-AN showed a significant lower preference for weight gain versus weight maintenance than HC (p = 0.011, η_p^2 = 0.107). Correlation between explicitly assessed drive for thinness and CA score was low. As expected, in FP-AN the explicitly endorsed fear of weight gain was confirmed by the marked preference for weight maintenance compared to HC, while for NFP-AN explicit and implicit measures diverged, indicating that against their self-report they may experience at least some fear of weight gain. The utility of CA as a tool to measure fear of weight gain — and potentially other psychopathological constructs —requires further confirmation.

Keywords: non-fat phobic anorexia nervosa, importance of shape and weight, conjoint analysis (CA), indirect measure, fear of weight gain

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INTRODUCTION

Individuals with anorexia nervosa (AN) who do not report fear of gaining weight or becoming fat, so called non-fat phobic anorexia nervosa (NFP-AN; Lee et al., 1993), seem to occur with a wide geographic distribution in both western and non-western populations and exhibit a consistent profile of low scores on measures of eating disorder pathology (Dalle Grave et al., 2008; Becker et al., 2009; Wildes et al., 2013). The changes made to the diagnostic criteria for AN within the fifth edition of the *DSM* (*DSM-5*, American Psychiatric Association [APA], 2013) which saw Criterion B altered to no longer make fear of weight gain a prerequisite for the diagnosis of AN, allow clinicians to classify NFP-AN as a *bona fide* variant of AN. Furthermore, while individuals with NFP-AN might exhibit lower psychopathology (Forbush and Wildes, 2017), they also present with higher treatment drop-outs, lower remission rates, and lower insight into their condition (Santonastaso et al., 2009).

The latter could be one possible explanation for their denial of fear of weight gain, besides having divergent rationales for food restriction (Becker et al., 2009; Lee et al., 2012) and minimizing or denying shape and weight concerns (Izquierdo et al., 2019). Thus, an identification and diagnosis of individuals with NFP-AN are essential to adequately shape treatment for this patient group, potentially with a less strong focus on alteration of body image disturbance.

An additional reason for the challenging nature of determining how NFP-AN should be classified is the manner in which the construct has been measured in the past. The research referenced above assessed the existence of fear of weight gain through self-report using explicit measures such as questionnaires, e.g., the Eating Disorder Inventory (EDI) (Garner et al., 1983), and especially its subscale Drive for Thinness, being vulnerable to underreporting due to denial of illness in AN (Vandereycken, 2006). However, there have been calls for the use of performance-based measures in NFP-AN to determine whether fear of weight gain may be present on an implicit level even if not explicitly endorsed (Thomas et al., 2013). The only study aiming to implicitly assess fear of weight gain in AN made use of implicit association tests (IATs) (Izquierdo et al., 2019). Results revealed that adolescents with and without reported fear of weight gain showed similar implicit biases toward dieting and thinness, but those with NFP-AN scored significantly lower on the explicit EDI-3 Drive for Thinness subscale than individuals with FP-AN. The lack of group differences on implicit measures may be ascribed to the use of a categorical approach to assess fear of weight gain. Yet, a dimensional approach to examine the association of implicit and explicit measures of fear of weight gain and eating psychopathology is lacking. This study highlights the novel information that can be gained by investigating both implicit and explicit measures in this group.

In addition to the IAT, a Conjoint Analysis (CA) could be a novel implicit measure to assess the relative importance of shape and weight. CA is a well-established method that has been predominantly used in market research and allows for the analysis of individual preferences for products in order to infer the relative importance of the features making up these products (Wittink and Cattin, 1989; Wittink et al., 1994). CA has been shown to be a reliable method to assess the view of a person (Ryan et al., 2001). Even though CA has mainly been utilized in commercial settings, it has recently gained popularity in psychological and medical settings and has been shown to be useful in evaluating wishes and attitudes in clinical populations (Haarig and Mühlig, 2015). In a related context, CA was used to detect implicit weight-based discrimination that participants denied when questioned explicitly (Caruso et al., 2009). It has, however, not been used to assess clinical symptoms before. There is a particular type of CA that has gained much popularity in recent years, i.e., the choice-based conjoint (CBC) analysis (Gensler, 2006), in which product preferences are measured indirectly by observing an individual's choices between alternatives. For example, respondents may be presented with and asked to choose between different mobile phone product profiles, which vary on characteristics such as brand, size, resolution, and price. Of each characteristic at least two variations should exist, e.g., at least two sizes of mobile phones, two prices, two brands and resolutions. These variations of characteristics were termed attributes for this piece of research. From the choices participants make, the relative importance score for each characteristic as well as the preference for the attributes within this characteristic (preference scores) are derived.

AN has an overpowering impact on all aspects of a patient's life, affecting relationships with friends, family and partners, the ability to perform within school or work settings and engage in pleasure activities (De Ruysscher et al., 2015). Thus, an examination of the relative importance of weight compared to these other factors in life may shed light on the discussion on denial of fear of weight gain in some individuals with AN. Therefore, we created life profiles representing scenarios that participants could choose for their own lives based on factors pertaining to interpersonal relationships, success, hobbies, security, and appearance/shape and weight, with the latter being the factor used as an indicator of fear of weight gain. These life profiles contained attributes that represented two opposing manifestations of these factors (e.g., factor: Appearance/Shape and Weight, attributes: weight maintenance and weight gain). Fifteen choice sets including two life profiles each were presented to the participants who had to choose one profile per choice set. It is important to note, that participants had to make a relative choice, e.g., between maintaining weight and not having a partner (see **Table 1**, profile 1) versus gaining weight and being in a stable partnership (profile 2).

The aim of this study was to test a novel implicit measure, that may be a useful tool for future discriminative analysis of absence of fear of weight gain in a subgroup of participants with AN. As a first step, we compared fear of weight gain in participants with FP-AN and healthy controls (HC) through an implicit or indirect measure, more specifically by measuring the importance of the factor "Appearance/Shape and Weight" and preference for attributes related to fear of weight gain when making choices between life profiles. Furthermore, for a dimensional approach to examine fear of weight gain, we aimed to investigate whether the extent of implicitly assessed importance and preference scores is associated with the extent of explicit questionnaire-based measures of eating disorder pathology, specifically fear of weight gain and body image disturbance in participants with

TABLE 1 | Example of a choice set presented within the choice based conjoint analysis.

Choice Set 1	
Profile 1	**Profile 2**
Don't have a partner	Are in a stable partnership
Have good relationships with friends and family	Don't have rewarding relationships with friends and family
Don't have any hobbies that give you joy	Don't have any hobbies that give you joy
Maintained your weight in the last 2 months and fit into your favorite jeans	Gained 3 kg in the last 2 months and don't fit into your favorite jeans
Are successful at work or school	Are successful at work or school
Worry about your financial situation	Worry about your financial situation

FP-AN and NFP-AN. Additionally, we aimed to conduct a preliminary exploratory analysis on the ratings of the CBC in a small subgroup of participants with NFP-AN.

We hypothesized that (1) participants with FP-AN would show significantly higher importance ratings on the factor "Appearance/Shape and Weight" than HC. Furthermore, we hypothesized that (2) participants with FP-AN would show a significantly higher preference for the attribute pertaining to weight maintenance versus weight gain within the factor "Appearance/Shape and Weight" than HC. We also hypothesized that (3) the relative importance score for the factor "Appearance/Shape and Weight" would show a significant positive, and the preference for the attribute pertaining to weight gain would show a significant negative correlation with explicit questionnaire-based measures of fear of weight gain and body-image disturbance.

MATERIALS AND METHODS

Participants

HC and participants with FP-AN and NFP-AN were recruited via clinics, psychotherapy out-patient treatment centers, counseling services, Facebook and other online communities, advertisements on online marketspaces such as eBay, digital noticeboards and noticeboards at universities, university mailing lists, and advertisements in local newspapers. Prospective participants contacted the research team via e-mail and an appointment for an initial telephone screening was agreed upon. During the telephone screening, the prospective participants were assessed for the following inclusion criteria: Being female; a minimum age of 15 years; fluent in written and spoken German as well as no history of mania, psychosis, substance abuse or suicidal ideation. Due to the nature of the experiments carried out within a larger project this study was part of, participants could have no pre-existing eye conditions or neurological disorders, and no history of epilepsy. HC could not have experienced any lifetime mental health disorder. Prospective participants with AN had to answer at least two of the five items of the SCOFF questionnaire (Morgan et al., 2000) with *yes* and have a body mass index (BMI) below 18.5 kg/m^2 in order to be invited to a further diagnostic appointment at the laboratory. From a total of n = 118 individuals who took part in the telephone screening, n = 51 had to be excluded as they met exclusion criteria. Participants with AN were classified as FP- or NFP-AN by means of the Drive for Thinness scale of the EDI-2 (Paul and Thiel, 2004; see below), with participants receiving a score equal to or below 7 being classified as NFP-AN and participants receiving a score above 7 being classified as FP-AN, which is in line with the classification in previous research (Becker et al., 2009).

Procedure

After arrival at the laboratory of the university outpatient clinic, participants first completed the informed consent process and additional parental assent was obtained for participants below the age of 18. The appointment typically lasted for 4–5 h. The lead researcher, a certified clinical psychologist, then completed structured clinical interviews (see below) with them, which would take up to 60 min. Unless the interviews indicated that inclusion criteria were not met (n = 1), research assistants completed the remaining tasks with the final set of participants (N = 66, HC: n = 29, FP-AN: n = 30, NFP-AN: n = 7). First, each participant was measured and weighed. Subsequently, a headless photo of the participants in standardized underwear was taken that was used for paradigms conducted after the CBC (eye-tracking, Hartmann et al., submitted; electroencephalography and startle, unpublished data). Afterward, participants were led to another room containing a laptop for the completion of the CBC. Participant were familiarized with the laptop and given instructions for the CBC. Participants were left alone for the completion of the CBC and given as much time as required. After the CBC, participants completed a subsequent Implicit Association Task (unpublished data) as well as the above mentioned paradigms. They also completed the questionnaires detailed below. Finally, the participants attended a debriefing with the lead researcher in which it was ensured that they had not suffered any major distress and were informed of the exact aims of the study, as well as paid the incentive of 70€. This study received ethical approval by the university's ethics committee of the last author.

Conjoint Analysis Task

As a basis for our CBC, we determined the following six factors as relevant: "Belonging/Intimacy," "Belonging/Interpersonal," "Leisure/Hobbies," "Appearance/Shape and Weight," "Success in Job or School," and "Security/Finances." Each factor contained two attributes which represented opposing manifestations of this factor. Of particular importance was the factor "Appearance/Shape and Weight" through which we assessed fear of weight gain. The attributes within this factor are very close in wording to items from the Anorexia-Fear-Scale (Schulze and Keller, 2009), a questionnaire developed to fear of weight gain which has been demonstrated to be a good indicator of this construct. The other factors were chosen in expert consensus since they represent aspects through which people tend to define their lives and are often heavily impacted by AN (De Ruysscher et al., 2015).

Upon entry of these factors and attributes into XLSTAT (XLSTAT 2014, 2014, Paris, France), so-called life profiles were created automatically using a full-profile, fractional factorial design. In a full-profile design participants are asked to make choices between complete profiles containing an attribute from each factor, as opposed to making choices between single attributes from within the same factor. This design was chosen as this is more closely modeled on choice scenarios which people might experience in real life and thus has higher external validity (Backhaus et al., 2016). The use of a fractional factorial design, i.e., a suitable fraction of all possible combinations of the factors, was necessary as a full factorial design would have resulted in a number of stimuli exceeding the amount participants can reliably evaluate (Backhaus et al., 2016). The typical CA design consisted of a median of 16 choice sets (Wittink and Cattin, 1989). Choice sets were generated applying an incomplete block design,

TABLE 2 | Sample characteristics.

	HC (*n* = 29)	NFP-AN (*n* = 7)	FP-AN (*n* = 30)	Test statistic (*F or H*)	Test χ^2 (df = 2)
Age (*M*, *SD*, range) years	23.28 (2.52, 19–28)	27.14 (11.67, 15–45)	25.53 (10.43, 17–58)	0.49	
BMI (*M*, *SD*)	21.41 (2.19)[b,c]	14.54 (3.80)[a]	16.14 (2.65)[a]	37.28***	
Marital status, *n* (%)					
In a romantic relationship	21 (72.41)	3 (42.86)	5 (6.67)		18.61***
Drive for Thinness EDI-2 (*M*, *SD*)	0.90 (2.53)[c]	2.71 (2.87)[c]	13.57 (4.12)[a,b]	50.61***	
BCQ total score (*M*, *SD*)	39.48 (11.19)[c]	43.57 (17.83)[c]	62.57 (18.80)[a,b]	16.54***	
BIAQ total score (*M*, *SD*)	37.76 (7.13)[c]	42.14 (8.93)[c]	58.87 (9.04)[a,b]	39.17***	
Sum score EDE items Importance of Weight, Importance of Shape and Fear of Weight Gain (*M*, *SD*)	2.28 (2.22)[c]	7.57 (5.94)	12.47 (4.34)[a]	41.34***	
Current psychotherapy, *n* (%)		4 (57.14)	7 (23.33)		12.42**
Past psychotherapy, *n* (%)					
Residential		5 (71.43)	15 (50.00)		27.66***
Semi-residential/day clinic		0 (0.00)	2 (6.66)		2.48
Out-patient		6 (85.72)	15 (50.00)		27.48***

*Superscripts denote significant differences from the two other groups: a = HC, b = NFP-AN, c = FP-AN. **p < 0.01, ***p < 0.001.*

TABLE 3 | Part-worth utilities and relative importance in the choice based conjoint analysis by group.

Factors	Attributes	HC	FP-AN	HC	FP-AN
Belonging/Intimacy	Are in a stable partnership	−12.5 (26.71)*	6.5 (33.50)*	8% (6.00)	9% (6.85)
	Don't have a partner	12.5 (26.71)*	−6.5 (33.50)*		
Belonging/Interpersonal	Have good relationships with friends and family	109.0 (39.57)	99.8 (49.50)	37% (10.74)	35% (12.22)
	Don't have rewarding relationships with friends and family	−109.0 (39.57)	−99.8 (49.50)		
Leisure/Hobbies	Have rewarding hobbies	−26.2 (50.29)	−2.9 (49.73)	16% (9.36)	13% (9.78)
	Don't have any hobbies that give you joy	26.2 (50.29)	2.9 (49.73)		
Appearance/Shape and Weight	Maintained your weight in the last 2 months and fit into your favorite jeans	−16.6(34.40)*	6.6 (33.78)*	11% (5.98)	9% (6.22)
	Gained 3 kg in the last 2 months and don't fit into your favorite jeans	16.6 (34.40)*	−6.6 (33.78)*		
Success in Job or School	Are successful at work or school	32.5 (38.78)*	−10.4 (50.98)*	13% (10.08)	15% (8.96)
	Have problems at work or school	−32.5 (38.78)*	10.4 (50.98)*		
Security/Finances	Feel financially secure	3.6 (55.67)	−1.2 (63.85)	14% (11.38)	19% (9.49)
	Worry about your financial situation	−3.6 (55.67)	1.2 (63.85)		

**p < 0.05 for Bonferroni test.*

i.e., each choice set contained only a selection of attributes of each factor, thus not all attributes appear in all of the choice sets (i.e., single attributes might be the same between the two profiles of each choice sets). A total of 15 choice sets containing two life profiles each were created and presented within an excel sheet. **Table 1** displays an example of a typical choice set used in our CBC, in which the two profiles share some attributes and also differ in others.

As participants do not rate the attributes themselves but a set of profiles formed by a combination of attributes at different levels, problems of social desirability are mitigated (e.g., Wallander, 2009; Horiuchi et al., 2018). Moreover, CA was shown to be more resistant to socially desirable responses than any other commonly used self-report measures, e.g., Likert-type choices (Tomassetti et al., 2016). Hence, also CBC designs are useful when sensitive features are assessed and the need for cover stories to mask the goal of the experiment is low (Dahl, 2018). In line with this, in our study, we did not use a cover story for the CBC, but rather told the participants to accomplish a choice task in which they select their preferred scenario from different fictive scenarios. Participants were instructed to read the given profiles carefully and then choose the profile that was most in line with what they would wish for in their own lives. Then, they were asked to enter their chosen profile into a box next to each choice set and scroll down to view the next two profiles. The utility-theoretic approach of discrete choice models postulates that respondents will choose the alternative that provides the highest possible utility to them (Eisen-Hecht et al., 2004). It is assumed that the utility of a product is determined by the individual, so called part-worth utilities assigned by the respondent to the attributes contained within it (Backhaus et al., 2016). The attributes are defined as the various manifestations or levels within a factor. The part-worth utilities thus describe the preference of a respondent for a specific attribute relative to the other attributes within the same factor. For this piece of research, it was assumed that part-worth utilities assigned to attributes by HC and participants with FP- and NFP-AN would be significantly different.

Measures

The following instruments were administered to participants in the following order:

Structured Clinical Interview for DSM-IV (SKID; German-language version: Wittchen et al., 1997): The SCID I is a semi-structured diagnostic interview used to determine Axis I disorders. For this study, the SCID I was used to determine if exclusion criteria were met. The interrater reliability is satisfactory to good ($0.61 \leq r_{icc} \leq 0.83$; Lobbestael et al., 2011).

Eating Disorder Examination (EDE 12.0D; German-language version: Hilbert and Tuschen-Caffier, 2006): The EDE interview assesses eating-disorder psychopathology and consists of a total of 22 items which can be assigned to the following four subscales: Restraint, Eating Concern, Weight Concern and Shape Concern. Another six items that are not included in the total or subscale scores are used for diagnostic purposes. For the present study, we made use of only three items, namely Importance of Shape, Importance of Weight, and Fear of Weight Gain, summarized to one sum score. The internal consistency of this EDE score in this study was good (Cronbach's $\alpha = 0.87$).

Eating Disorder Inventory 2 (EDI-2; German-language version: Paul and Thiel, 2004): The EDI-2 consists of 91 items measuring eating-disorder psychopathology. In this study we used only the subscale Drive for Thinness subscale, which assesses the frequency of behaviors, thoughts and feelings that concern drive for thinness and fear of weight gain. The EDI-2 subscale Drive for Thinness showed acceptable internal consistency in the current study (Cronbach's $\alpha \leq 0.77$).

Body Checking Questionnaire (BCQ; German-language version: Vocks et al., 2008): The BCQ consists of 23 items and measures body checking behavior related to eating disorders associated with a negative body image. The total score had excellent internal consistency in our sample (Cronbach's $\alpha \leq 0.95$).

Body Image Avoidance Questionnaire (BIAQ; German-language version: Legenbauer et al., 2007): The BIAQ is a questionnaire made up of 19 items measuring avoidance behaviors regarding clothing and social activities. The total score had good internal consistency in the current study (Cronbach's $\alpha = 0.89$).

Statistical Analysis

To evaluate demographic and psychosocial differences between groups, we conducted univariate analyses of variance (ANOVAs) with Bonferroni-corrected *post hoc* comparisons (for continuous variables) and Kruskal–Wallis H test with *post hoc* pairwise Dunn–Bonferroni comparisons or χ^2 tests (for categorical variables). The further statistical analyses consisted of two main stages: The analysis of group differences in the CBC analysis and the correlational analysis of the CBC results and questionnaire data.

Group Differences in the CBC Analysis

The Hierarchical Bayes analysis (Allenby and Rossi, 2006), conducted in XLSTAT, follows an iterative process in which empirical choice data is used to estimate individual part-worth utilities, which in turn are used to estimate the distribution of these values on an aggregate level. The aggregate level data is then used to improve the part-worth utility estimates. This process is repeated until estimates cannot be improved further. Based on the individual and aggregate level part-worth utilities the importance of factors within the decision-making process can be determined. For this the ranges of part-worth utilities within each factor are calculated and converted into percentages, resulting in relative importance scores summing up to 100%. The part-worth utilities estimated by XLSTAT were converted to zero-centered differences for the purpose of further analysis. This was necessary in order to counteract the potential effects of response error within the sample on part-worth utilities and to ensure accurate results of the significance tests which were conducted thereafter.

We conducted all subsequent analyses in SPSS version 24.0 (IBM Corp., 2016, Chicago, IL, United States). The relative importance scores for the factors "Belonging/Intimacy," "Leisure/Hobbies," "Appearance/Shape and Weight," and "Success in Job or School" showed significant skew and kurtosis. Log and square root transformations failed to produce non-significant skew and kurtosis, so we used the non-parametric Mann–Whitney U test to test for group differences within these factors. We tested the remaining factors and attributes for significant differences between groups with independent one-way analyses of variance (ANOVA). Pairwise comparisons were conducted via Bonferroni tests as this is recommended for use if the number of contrasts of interest does not exceed the number of factor levels (Kao and Green, 2008). As measures of effect size, partial η^2 for parametric and η^2 for non-parametric tests were reported (small = 0.01; medium = 0.06; large = 0.14).

Correlational Analysis

We calculated a total of 6 correlations across all participants with AN. The BIAQ, BCQ, EDI-2 Drive for Thinness, and sum score of the items Importance of Weight, Importance of Shape and Fear of weight gain from the EDE were each correlated with the relative importance score for the factor "Appearance/Shape and Weight" and the part-worth utility of the attribute "Gained 3 kg in the last 2 months and don't fit into your favorite jeans." The part-worth utility for the aforementioned attribute and the scores from all of the above questionnaires showed significant skew and kurtosis. Log and square root transformations failed to produce non-significant skew and kurtosis for all of the above except the scores obtained from the BCQ for which a log transformation was performed. For this reason, we calculated the non-parametric Spearman correlation for all correlations mentioned above apart from the correlation between the BCQ score and the relative importance score for which we calculated a Pearson's correlation (r small = 0.1; medium = 0.3; large = 0.5).

Exploratory Analysis of Subgroup Differences

The relative importance scores for the factors "Belonging/Intimacy," "Belonging/Interpersonal," "Success in Job or School," and "Finance" showed significant skew and kurtosis, so we used the non-parametric Mann–Whitney *U* test to test for group differences within these factors. We tested the remaining factors and all attributes for significant differences between groups with independent one-way analyses of variance (ANOVA).

RESULTS

Participants' Characteristics

Table 2 presents sociodemographic and clinical characteristics of the three groups. Groups did not significantly differ in age, but as expected both groups with AN had a significantly lower BMI than the HC group. In all questionnaire scores, FP-AN scored significantly higher than HC and, except from the sum score of the EDE items, also significantly higher than NFP-AN.

Group Differences in the CBC Analysis

Table 3 displays the estimation results of the CBC analysis by group. The report of results of the CBC analysis are started with the presentation of the factor "Appearance/Shape and Weight" as this is the one in focus in this manuscript, followed by the other factors in order of display in **Table 3**.

There were no significant differences between the relative importance scores of the groups for the factor "Appearance/Shape and Weight," $U = 353.00$, $p = 0.214$, $\eta^2 = 0.026$. For both groups, HC and participants with FP-AN, it was the fifth most important. A significant effect for group on part-worth utilities was found, $F(1,57) = 6.84$, $p = 0.011$, $\eta_p^2 = 0.107$, with participants with FP-AN showing a significantly higher preference for the attribute pertaining to maintaining weight versus gaining weight than HC.

The factor "Belonging/Intimacy" held the lowest relative importance when choosing a life profile for all groups. The part-worth utilities of the attributes within this factor reveal that both groups of participants with FP-AN preferred being in a stable relationship over not having a partner, whilst HC gave preference to the latter in order to choose positive attributes in other life domains. Relative importance scores, $U = 473.00$, $p = 0.565$, $\eta^2 = 0.006$ did not vary significantly across groups. The part-worth utilities revealed a significant higher preference for being in a partnership for participants with FP-AN than HC, $F(1,57) = 3.04$, $p = 0.019$, $\eta_p^2 = 0.093$.

The factor "Belonging/Interpersonal" had the greatest impact on the choice of life profile for HC and participants with FP-AN. The relative importance ratings for this factor did not vary significantly across groups, $F(1,57) = 0.49$, $p = 0.485$, $\eta_p^2 = 0.009$. The part-worth utilities of the attributes within this factor reveal a pronounced preference for rewarding relationships with friends or family over a lack of these for all groups. Part-worth utilities did not vary significantly across groups for these attributes, $F(1,57) = 0.62$, $p = 0.433$, $\eta_p^2 = 0.011$.

"Leisure/Hobbies" was the second most important factor when choosing a life profile for HC, the fourth most important for participants with FP-AN. No significant effect for group on relative importance scores for this factor was detected, $U = 341.00$, $p = 0.154$, $\eta^2 = 0.034$. The part-worth utilities showed that all groups had a stronger preference for not having any rewarding hobbies over having rewarding hobbies in order to get what they want in other life domains, with no significant differences between groups, $F(1,57) = 3.20$, $p = 0.079$, $\eta_p^2 = 0.053$.

No significant effect was found on the relative importance scores for the factor "Success in Job or School," $U = 488.00$, $p = 0.422$, $\eta_p^2 = 0.011$. Participants with FP-AN rated it the third most important factor and for HC the fourth most important. A significant effect for group on the part-worth utilities was also shown, $F(1,57) = 13.16$, $p = 0.001$, $\eta_p^2 = 0.188$, with HC showing a significantly higher preference for being successful at work or school than participants with FP-AN.

The factor "Security/Finances" was second most important for participants with FP-AN and third most important for HC and participants with NFP-AN, with no significant effect for group on relative importance of this factor, $F(2,63) = 1.42$, $p = 0.250$, $\eta_p^2 = 0.043$. No significant effect for group on part-worth utilities could be detected either $F(1,57) = 0.10$, $p = 0.759$, $\eta_p^2 = 0.002$. HC also showed preference for feeling financially secure. Participants with FP-AN showed a preference for worrying about their financial situation.

Correlational Analyses

We found no significant correlations between the part-worth utility, the relative importance score of the factor "Appearance/Shape and Weight," and questionnaires. **Table 4** displays the results of the correlational analyses.

Exploratory Analyses of Subgroups

No significant effect for group was found on the relative importance of the factor "Appearance/Shape and Weight," $F(1,34) = 1.74$, $p = 0.179$, $\eta_p^2 = 0.049$, being the fourth most important for participants with NFP-AN. The part-worth utilities did not vary significantly across both groups, $F(1,34) = 2.66$, $p = 0.112$, $\eta_p^2 = 0.072$, but there was a pronounced preference for weight maintenance over weight gain in participants with NFP-AN, part-worth-utility of 9.6 (*SD* 52.72) vs. −16.6 (*SD* 33.78) for HC.

There were no significant differences between the relative importance scores of the groups for the factor

TABLE 4 | Correlations between relative importance of Appearance and part-worth utility of Weight Gain in the choice based conjoint analysis results and questionnaires.

	Drive for thinness (EDI-2)	BCQ total score	BIAQ total score	Sum score of three EDE-items[1]
Relative Importance				
Appearance/Shape and Weight	−0.06	−0.16	−0.16	−0.31
Part-Worth Utility				
Gained 3 kg in the last 2 months and don't fit into your favorite jeans	−0.04	−0.14	−0.02	−0.14

[1] *Items: Importance of Weight, Importance of Shape, Fear of Weight Gain.*

"Belonging/Intimacy," $U = 100.00$, $p = 0.969$, $\eta^2 = 0$. No significant effect for group on part-worth utilities could be detected either, $F(1,34) = 1.37$, $p = 0.249$, $\eta_p^2 = 0.039$. Participants with NFP-AN preferred being in a stable relationship over not having a partner, whilst HC gave preference to the latter in order to choose positive attributes in other life domains.

The factor "Belonging/Interpersonal" was the second most important for those with NFP-AN. The relative importance ratings for this factor varied significantly across groups, $U = 39.0$, $p = 0.011$, $\eta^2 = 0.173$. Part-worth utilities also varied significantly across both groups for these attributes, $F(1,34) = 6.49$, $p = 0.016$, $\eta_p^2 = 0.160$, with participants with NFP-AN showing significantly lower preference for having rewarding relationships with friends and family than HC.

"Leisure/Hobbies" was the fifth most important factor for participants with NFP-AN. No significant effect for group on relative importance scores for this factor was detected, $F(1,34) = 1.38$, $p = 0.248$, $\eta_p^2 = 0.039$. The part-worth utilities revealed no significant differences between groups, $F(1,34) = 0.62$, $p = 0.436$, $\eta_p^2 = 0.018$.

For participants with NFP-AN, the factor "Success in Job or School" was the most important when choosing a life profile, placing significantly more importance on it than HC ($U = 151.00$, $p = 0.049$, $\eta^2 = 0.109$). No significant effect for group on part-worth utilities was found, $F(1,34) = 0.70$, $p = 0.408$, $\eta_p^2 = 0.020$.

The factor "Security/Finances" was third most important for both groups, with no significant effect for group on relative importance of this factor, $U = 121$, $p = 0.456$, $\eta^2 = 0.017$. No significant effect for group on part-worth utilities could be detected either $F(1,34) = 0.75$, $p = 0.394$, $\eta_p^2 = 0.021$.

DISCUSSION

The aim of this study was to test a novel implicit measure of fear of weight gain in participants with AN and HCs, specifically by measuring the relative importance of appearance and preference for attributes related to fear of weight gain when making choices between various life profiles with the help of a CBC analysis. Furthermore, for a dimensional approach to fear of weight gain we aimed to examine the correlations between implicit and several explicit measures of fear of weight gain and behavioral manifestations of a body-image disturbance.

In disagreement with our first hypothesis, individuals with FP-AN and HC did not differ on the relative importance of the factor "Appearance/Shape and Weight." Our second hypothesis was confirmed since participants with FP-AN showed a significantly lower preference for weight gain versus weight maintenance compared to HC. Contrary to the third hypothesis, all correlations between implicit and explicit measures of fear of weight gain were non-significant.

At first glance, the lack of group differences between participants with FP-AN and HC with regard to the relative importance of appearance seems counterintuitive, as patients with AN often seem to sacrifice important aspects of their lives in order to maintain their low weight (Serpell et al., 1999; Roux et al., 2016). Also, when evaluating self-worth, the overpowering predominance of shape and weight over other important aspects in life in samples with ED becomes evident (Fairburn et al., 2008). In contrast, in this sample, the relative importance of "Appearance/Shape and Weight" was low, being in fourth and fifth place. As participants in this study were asked to choose the life profiles they would wish most for, rather than the profile that most closely resembled their current life, our results may be evidence of the disconnect between what patients with AN wish for and what they achieve in their lives, rather than an indication of their current attitude toward weight gain. Furthermore, as the majority of our patients with AN endorsed in past psychotherapy, they might have already worked on this topic during their sessions. Exploring and understanding these results in greater detail, it is important to examine the preferences for the attributes within this factor. As expected, participants with FP-AN showed a significantly lower preference for weight gain versus weight maintenance compared to HC. The difference between the part-worth utilities for both attributes is much higher for HC than for participants with FP-AN, signifying that the preference for weight gain in HC is more pronounced than the opposing preference in participants with FP-AN. This suggests that HC may experience less ambivalence regarding the choice between weight maintenance and gain and may actively choose weight gain in order to secure positive rewards in other areas of their lives compared to individuals with FP-AN.

Evaluating the relative importance of the other factors of the life profiles, our results revealed no significant differences in the relative importance placed on the various factors between FP-AN and HC. This supports a study on explicit life goals in patients with AN and BN compared to HC (Hötzel et al., 2012) showing that individuals with AN and BN generally pursued the same goals in life as HC, but exhibited deficits in goal realization.

A preliminary exploratory subgroup analysis on participants with NFP-AN and HC also revealed no significant difference in the relative importance of appearance between the two groups. Yet, looking at the part-worth utilities, it is of note that NFP-AN participants' preference for weight maintenance vs. weight gain became apparent, which was even more pronounced than those of participants with FP-AN, still tentatively suggesting that contrary to their self-report, they may experience fear of weight gain. These results are in line with the findings on adolescents and young women with NFP-AN (Izquierdo et al., 2019) and could reflect an explicit denial of fear of weight gain while facing an unconscious fear of weight gain at the same time. It is also of note that participants with NFP-AN put a significant higher relative importance on success in job or school while they showed a significantly lower relative importance on the factor interpersonal/belonging than HC. High importance of being successful could be related to the high level of perfectionism found in samples with AN (Hartmann et al., 2014) which could be even higher in NFP-AN. It may also be that being successful in job or school is more compatible with a very low weight than maintaining a good relationship with friends and family. Further support for this possible explanation is the finding that, also in line with prior research (Santonastaso et al., 2009), the BMI of our individuals with NFP-AN was even lower than in FP-AN. Yet, against this hypothesis, participants with FP-AN showed a significant lower preference for being successful in job or school than HC. Taking all together, these preliminary results may be interpreted in a way that NFP-AN seem to be less ambiguous in their life choices, including their weight, and therefore differ more in their profile from HC than FP-AN. Yet, the findings regarding the comparison of NFP-AN and HC have to be interpreted with caution due to the small sample size of participants with NFP-AN.

For a dimensional analysis of implicit fear of weight gain in AN, we were also interested in the correlations between importance and preference score and questionnaire-based measures of fear of weight gain and behavioral manifestations of a body-image disturbance. The direction of the correlations between the questionnaire-based measures and the part-worth utility of the attribute within "Appearance/Shape and Weight" were as expected—negative for "Gained 3 kg in the last 2 months and don't fit into your favorite jeans." Yet, contrary to our expectations, all correlations were non-significant and small, again suggesting only a tenuous connection between what was measured with the help of the questionnaires and what was assessed through the CBC analysis. Several reasons for the discrepancy of implicit and explicit measures have been discussed in literature (e.g., Hofmann et al., 2005; Roefs et al., 2011), e.g., motivational biases in self-reports, independence of the underlying constructs, and lack of introspection. Both the characteristic of the CBC instruction and the idea of a minimizing response style in NFP-AN (Izquierdo et al., 2019), these factors could play a role for these results left open to discuss.

This piece of research was subject to certain limitations. The sample size for the group of participants with NFP-AN was very small, resulting in low statistical power which may mean small statistical differences were not detected and results for participants with NFP-AN should be interpreted with caution. Further research with larger sample sizes should be carried out on NFP-AN to allow for more definite and generalizable conclusions. Although the NFP phenotype seems to be stable during treatment (Dalle Grave et al., 2008; Carter and Bewell-Weiss, 2011) and over 12-month follow-up (Wildes et al., 2013), we cannot rule out that previous treatment changed the EDI-2 Drive for Thinness score used to categorize the two AN subgroups. Furthermore, the HC group mainly consisted of students between the ages of 19 and 28, calling into question the representativeness of this group for the general population. It also needs to be considered whether the instruction given during the CBC analysis, to choose the life profile most wished for, was appropriate for assessing the current feelings of the participants toward weight gain. The wording of the task was originally based on the idea that the core concept, i.e., fear of weight gain, is rather future-oriented in nature (Murray et al., 2016). As touched on above, the results may be more indicative of the future goals and wishes of the participants rather than their present state of mind. Asking participants to, for example, choose the life profile they most identified with might have been a more suitable directive considering the research question. Looking at the strengths of this study, this was the first study implicitly assessing fear of weight gain in adult participants with NFP- and FP-AN who had been thoroughly diagnosed using a structured clinical interview. We employed CA (a reliable and popular method in commercial settings) as a novel method in this clinical context.

Conclusively, it can be said that the results of this study indicate that we did succeed in measuring fear of weight to some extent. The preferences for the attributes within the factor "Appearance/Shape and Weight" revealed the marked preference for weight maintenance of participants with AN and for weight gain in HC which is in line with our expectations and thus confers face validity. Participants with NFP-AN showed a strong preference for weight maintenance indicating that, in line with Izquierdo et al. (2019), they may experience fear of weight gain though explicitly denying it. However, the real and sole influence of fear of weight gain on the answering pattern is hard to distinguish in this paradigm, as the results for all factors and attributes are relative to and impact each other. It thus can be concluded that there is some utility of CA as a diagnostic tool for measuring fear of weight gain and it might be of great value in clinical and especially therapeutic settings as a means for therapists and patients to gain insight into the specific goals of patients and to identify potential conflicts between these goals.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The study protocol was approved by the Ethics Committee of Osnabrück University. Written informed consent to participate in this study was provided by the participants and (if minor) her/his legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JT and AH planned the study. LR and AH carried out the assessment. SV supervised it. JK analyzed the data and wrote the manuscript. All authors critically edited the manuscript.

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REFERENCES

Allenby, G. M., and Rossi, P. E. (2006). "Hierarchical bayes models, II," in *The Handbook of Marketing Research: Uses, Misuses, and Future Advances*, eds R. Grover, and M. Vriens, (Thousand Oaks, CA: Sage Publications), 418–440 doi: 10.4135/9781412973380.n20

American Psychiatric Association [APA] (2013). *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*. Washington, DC: American Psychiatric Association.

Backhaus, K., Erichson, B., Plinke, W., and Weiber, R. (2016). *Multivariate Analysemethoden*. Berlin: Springer.

Becker, A. E., Thomas, J. J., and Pike, K. M. (2009). Should non-fat-phobic anorexia nervosa be included in DSM-V? *Int J. Eat. Dis.* 42, 620–635. doi: 10.1002/eat.20727

Carter, J. C., and Bewell-Weiss, C. V. (2011). Nonfat phobic anorexia nervosa: clinical characteristics and response to inpatient treatment. *Int. J. Eat. Dis.* 44, 220–224. doi: 10.1002/eat.20820

Caruso, E. M., Rahnev, D. A., and Banaji, M. R. (2009). Using conjoint analysis to detect discrimination: revealing covert preferences from overt choices. *Soc. Cogn.* 27, 128–137. doi: 10.1521/soco.2009.27.1.128

Dahl, M. (2018). *Social Desirability Bias in Candidate Conjoint Experiments*. Copenhagen: Department of Political Science, University of Copenhagen.

Dalle Grave, R., Calugi, S., and Marchesini, G. (2008). Underweight eating disorders without overevaluation of shape and weight: atypical anorexia nervosa? *Int. J. Eat. Dis.* 41, 705–712. doi: 10.1002/eat.20555

De Ruysscher, C., Annicq, P., Vandevelde, S., and Claes, C. (2015). Anorexia nervosa: een integratief behandelmodel. *Tijdschr. Psychother.* 41, 87–100. doi: 10.1007/s12485-015-0015-x

Eisen-Hecht J. I, Kramer, R. A., and Huber, J. (2004). A hierarchical Bayes approach to modeling choice data: a study of wetland restoration programs. *Paper Presented at the American Agricultural Economics Association Annual Meeting*, Denver, CO.

Fairburn, C. G., Cooper, Z., Shafran, R., Bohn, K., Hawker, D. M., Murphy, R., et al. (2008). "Shape concern, shape checking, feeling fat and mindsets," in *Cognitive Behavior Therapy and Eating Disorders*, ed. C. G. Fairburn, (New York, NY: Guilford Press), 96–123.

Forbush, K. T., and Wildes, J. E. (2017). Application of structural equation mixture modeling to characterize the latent structure of eating pathology. *Int. J. Eat. Dis.* 50, 542–550. doi: 10.1002/eat.22634

Garner, D. M., Olmstead, M. P., and Polivy, J. (1983). Development and validation of a multidimensional eating disorder inventory for anorexia nervosa and bulimia. *Int. J. Eat. Dis.* 2, 15–34. doi: 10.1002/1098-108x(198321)2:2<15::aid-eat2260020203>3.0.co;2-6

Gensler, S. (2006). Ermittlung von präferenzen für produkteigenschaften mit hilfe der choice-based conjoint analyse, Teil I. *WiSt* 35, 254–258. doi: 10.15358/0340-1650-2006-5-254

Haarig, F., and Mühlig, S. (2015). Nutzung von conjoint-analysen zur messung von therapiezielpräferenzen aus patientenperspektive in der behandlung psychischer störungen. *Z. Klin. Psychol. Psychother.* 44, 1–16. doi: 10.1026/1616-3443/a000287

Hartmann, A. S., Thomas, J. J., Greenberg, J. L., Matheny, N. L., and Wilhelm, S. (2014). A comparison of self-esteem and perfectionism in anorexia nervosa and body dysmorphic disorder. *J. Nerv. Ment. Dis.* 202, 883–888. doi: 10.1097/NMD.0000000000000215

Hilbert, A., and Tuschen-Caffier, B. (2006). *Eating Disorder Examination: Deutschsprachige Übersetzung*. Münster: Verlag für Psychotherapie.

Hofmann, W., Gawronski, B., Gschwendner, T., Le, H., and Schmitt, M. (2005). A meta-analysis on the correlation between the implicit association test and explicit self-report measures. *Pers. Soc. Psychol. Bull.* 31, 1369–1385. doi: 10.1177/0146167205275613

Horiuchi, Y., Markovich, Z. D., and Yamamoto, T. (2018). "Does Conjoint Analysis Mitigate Social Desirability Bias?," *MIT Political Science Department Research Paper No. 2018–2015*. Hanover, NH.

Hötzel, K., Michalak, J., Striegler, K., Dörries, A., von Brachel, R., Braks, K., et al. (2012). Explizite Lebensziele von Patientinnen mit anorexia und bulimia nervosa. *Verhaltenstherapie* 22, 173–180. doi: 10.1159/000341538

IBM Corp. (2016). IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.

Izquierdo, A., Plessow, F., Becker, K. R., Mancuso, C. J., Slattery, M., Murray, H. B., et al. (2019). Implicit attitudes toward dieting and thinness distinguish fat-phobic and non-fat-phobic anorexia nervosa from avoidant/restrictive food intake disorder in adolescents. *Int. J. Eat. Dis.* 52, 419–427. doi: 10.1002/eat.22981

Kao, L. S., and Green, C. E. (2008). Analysis of variance: is there a difference in means and what does it mean? *J. Surg. Res.* 144, 158–170. doi: 10.1016/j.jss.2007.02.053

Lee, S., Ho, T. P., and Hsu, L. G. (1993). Fat phobic and non-fat phobic anorexia nervosa: a comparative study of 70 Chinese patients in Hong Kong. *Psychol. Med.* 23, 999–1017. doi: 10.1017/S0033291700026465

Lee, S., Ng, K. L., Kwok, K. P., Thomas, J. J., and Becker, A. E. (2012). Gastrointestinal dysfunction in Chinese patients with fat-phobic and nonfat-phobic anorexia nervosa. *Transcult. psychiatry* 49, 678–695. doi: 10.1177/1363461512459487

Legenbauer, T., Vocks, S., and Schütt-Strömel, S. (2007). Validierung einer deutschsprachigen version des body image avoidance questionnaire BIAQ. *Diagnostica* 53, 218–225. doi: 10.1026/0012-1924.53.4.218

Lobbestael, J., Leurgans, M., and Arntz, A. (2011). Inter-rater reliability of the structured clinical interview for DSM-IV Axis I disorders (SCID I) and Axis II disorders (SCID II). *Clin. Psychol. Psychother.* 18, 75–79. doi: 10.1002/cpp.693

Morgan, J. F., Reid, F., and Lacey, J. H. (2000). The SCOFF questionnaire: a new screening tool for eating disorders. *West. J. Med.* 172, 164–165. doi: 10.1136/ewjm.172.3.164

Murray, S. B., Loeb, K. L., and Le Grange, D. (2016). Dissecting the core fear in anorexia nervosa: can we optimize treatment mechanisms? *JAMA Psychiatry* 73, 891–892. doi: 10.1001/jamapsychiatry.2016.1623

Paul, T., and Thiel, A. (2004). *EDI-2: Eating Disorder Inventory*, 2nd Edn. Göttingen: Hogrefe Verlag.

Roefs, A., Huijding, J., Smulders, F. T., MacLeod, C. M., de Jong, P. J., Wiers, R. W., et al. (2011). Implicit measures of association in psychopathology research. *Psychol. Bull.* 137, 149–193. doi: 10.1037/a0021729

Roux, H., Ali, A., Lambert, S., Radon, L., Huas, C., Curt, F., et al. (2016). Predictive factors of dropout from inpatient treatment for anorexia nervosa. *BMC psychiatry* 16:339. doi: 10.1186/s12888-016-1010-7

Ryan, M., Scott, D. A., Reeves, C., Bate, A., Russell, E. M., Napper, M., et al. (2001). Eliciting public preferences for healthcare: a systematic review of techniques. *Health Technol. Assess.* 5, 1–186.

Santonastaso, P., Bosello, R., Schiavone, P., Tenconi, E., Degortes, D., and Favaro, A. (2009). Typical and atypical restrictive anorexia nervosa: weight history, body image, psychiatric symptoms, and response to outpatient treatment. *Int. J. Eat. Dis.* 42, 464–470. doi: 10.1002/eat.20706

Schulze, U. M., and Keller, F. (2009). Entwicklung eines fragebogens zur gewichtsassoziierten angst bei der anorexia nervosa. *Z. Kinder Jugendpsychiatr. Psychother.* 37, 195–202. doi: 10.1024/1422-4917.37.3.195

Serpell, L., Treasure, J., Teasdale, J., and Sullivan, V. (1999). Anorexia nervosa: friend or foe? *Int. J. Eat. Dis.* 25, 177–186. doi: 10.1002/(SICI)1098-108X(199903)25:2<177:AID-EAT7<3.0.CO;2-D

Thomas, J. J., Hartmann, A. S., and Killgore, W. D. (2013). Non-fat-phobic eating disorders: why we need to investigate implicit associations and neural correlates. *Int. J. Eat. Dis.* 46, 416–419. doi: 10.1002/eat.22098

Tomassetti, A. J., Dalal, R. S., and Kaplan, S. A. (2016). Is policy capturing really more resistant than traditional self-report techniques to socially desirable responding? *Organ. Res. Methods* 19, 255–285. doi: 10.1177/1094428115627497

Vandereycken, W. (2006). Denial of illness in anorexia nervosa—a conceptual review: part 1 diagnostic significance and assessment. *Eur. Eat. Dis. Rev.* 14, 341–351. doi: 10.1002/erv.721

Vocks, S., Moswald, C., and Legenbauer, T. (2008). Psychometrische überprüfung einer deutschsprachigen fassung des body checking questionnaire (BCQ). *Z. Klin. Psychol. Psychother.* 37, 131–140. doi: 10.1026/1616-3443.37.2.131

Wallander, L. (2009). 25 years of factorial surveys on sociology: a review. *Soc. Sci. Res.* 38, 505–520. doi: 10.1016/j.ssresearch.2009.03.004

Wildes, J. E., Forbush, K. T., and Markon, K. E. (2013). Characteristics and stability of empirically derived anorexia nervosa subtypes: towards the identification of homogeneous low-weight eating disorder phenotypes. *J. Abnorm. Psychol.* 122, 1031–1041. doi: 10.1037/a0034676

Wittchen, H.-U., Zaudig, M., and Fydrich, T. (1997). *Strukturiertes Klinisches Interview für DSM-IV*. Göttingen: Hogrefe.

Wittink, D. R., and Cattin, P. (1989). Commercial use of conjoint analysis: an update. *J. Mark.* 53, 91–96. doi: 10.1177/002224298905300310

Wittink, D. R., Vriens, M., and Burhenne, W. (1994). Commercial use of conjoint analysis in Europe: results and critical reflections. *Int. J. Res. Mark.* 11, 41–52. doi: 10.1016/0167-8116(94)90033-7

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The Body Image Approach Test (BIAT): A Potential Measure of the Behavioral Components of Body Image Disturbance in Anorexia and Bulimia Nervosa?

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A disturbed body image with fluctuating behavioral patterns of body related avoidance (BA) and body checking (BC) characterizes individuals with eating disorders (EDs) such as anorexia (AN) or bulimia nervosa (BN). So far, these behavioral body image components are mostly assessed via self-report instruments thereby neglecting their behavioral and partially automatic characteristics. Therefore, behavioral measures of BA and BC are needed. The present study investigates a behavioral assessment task for BA and BC in a sample of patients with diagnosed EDs and healthy controls. The sample consisted of 40 women diagnosed with either BN (N = 19) or AN (N = 21; ED sample) and 24 non-eating disordered, healthy female controls (HC). Within the Body Image Approach Task (BIAT) participants viewed photos of their own body (self-image) and a matched control body (other-image) by zooming the photos closer toward them (image became more focused) on the screen. The BIAT yields zoom-levels recorded separately for self- relative to other-images. Further measures were attractiveness ratings of these body images as well as questionnaire measures of BA, BC, and general ED symptomatology. Results showed that despite strong body dissatisfaction and clearly negative ratings of self- relative to other-images in both EDs, no group differences were found in approach to self-images on zoom-level as measured with the BIAT. Correlational analysis in each group indicated that zoom-level was positively related to BA scores in the HC group only. Yet, stepwise regression analyses revealed that attractiveness ratings explained most of the variance accounted by BA in predicting zoom-level. In sum, the BIAT seems suitable to assess BA and self-rated body attractiveness, but only in healthy individuals with subclinical levels on these constructs. It does not seem to capture the body image satisfaction or the behavioral components of body image disturbances in AN or BN or it conflates the opposed influences of BA and BC. Further experimentation is needed to adapt measures of behavioral body image components to the processes evoked in patients with ED during confrontation with body images.

Keywords: body image, body image avoidance, body checking, behavior approach test, eating disorder

INTRODUCTION

Eating disorders (ED) are characterized by pervasive body image disturbances (BID). In Anorexia nervosa (AN), perceptual and attitudinal aspects of BID are classified as necessary diagnostic criteria in the Diagnostic and Statistical Manual for Mental Disorders (DSM-V, American Psychiatric Association [APA], 2013); whereas Bulimia nervosa (BN) criteria require presence of the attitudinal aspects only. This emphasizes the multifaceted nature of BID symptoms which range from perceptual deficits (e.g., seeing oneself fatter than one is), cognitive-affective/attitude distortion (e.g., thinking negatively about one's body) to dysfunctional body-related behaviors such as checking (BC) and avoidance behavior (BA; e.g., Cash and Deagle, 1997; Legenbauer et al., 2013, 2017; Vossbeck-Elsebusch et al., 2015). Evidence for perceptual and cognitive-affective BID symptoms in ED patients is accumulating, whereas research focusing on body-image related *behavior* is still scarce. This neglected component however seems to exert significant influence on maintenance processes (Fairburn et al., 2003; Shafran et al., 2004; Williamson et al., 2004; Vossbeck-Elsebusch et al., 2015) by for example reducing body-related anxiety through certain safety behaviors (Mountford et al., 2006; Radix et al., 2018).

In order to understand and treat this BID component successfully, valid and comprehensive assessment instruments of BC and BA are required. Up to now, the behavioral component of BID has been assessed via self-report measurements such as the Body Checking Questionnaire (BCQ; Reas et al., 2002) or the Body Image Avoidance Questionnaire (BIAQ; Rosen et al., 1991). Results of studies using these self-report instruments show significant correlations with other aspects of BID and with body weight (e.g., Rosen et al., 1991; Legenbauer et al., 2007; Mountford et al., 2007; Bamford et al., 2014). This former research may be limited as self-report-based assessments can lead to biased results due to self-presentation tendencies and insensitivity to more automatic and implicit behaviors (with possible differences between AN and BN and interferences with severity). To overcome this limitation and to broaden the understanding of behavioral BID in EDs, behavioral assessment should be implemented.

While there is recently a growing number of studies that used variations of the Approach-Avoidance-Task (AAT) in the context of BID or disturbed eating behavior, there are only three studies known to us that tried to capture BA and BC with a behavioral assessment. The first one applied a stimulus response compatibility task in a student sample, where participants were asked to categorize pictures of models either as thin or chubby by moving a manikin symbol to or away from the model picture (Woud et al., 2011). Results showed faster approach than avoidance to thin models; no difference in approach-avoidance tendencies was found for chubby models. The approach – avoidance tendencies were associated to general symptoms of ED (thin internalization, drive to thinness, body dissatisfaction, etc.). More recently, Dondzilo et al. (2019) applied an AAT in undergraduate females with thin-ideal vs. non-thin pictures. Results confirmed hypothesized approach tendencies toward thin-ideal bodies and showed an avoidance bias for non-thin body pictures. Higher levels of body dissatisfaction, thin-ideal internalization and dietary restraint were associated with greater approach bias, whereas avoidance behavior was not correlated with self-reported levels of eating disturbances and BID. There is only one study (Leins et al., 2018) that applied the AAT in women with self-reported eating disturbances (categorized as ED symptoms present vs. absent based on Eating Disorder Examination Questionnaire cut-off scores according to Mond et al., 2004): participants were asked to operate a joystick to either push or pull images of normal weight or underweight pictures toward or away from them (images would zoom larger in proportion to joystick pull movement and zoom smaller for push movements). They failed to replicate the former finding of an approach bias toward thin pictures. Crucially, however, none of these studies used pictures of the participants' own body, neglecting empirical data that emphasize biased information processing in particular for own body related stimuli (e.g., Jansen et al., 2005, 2006; Roefs et al., 2008; von Wietersheim et al., 2012; Tuschen-Caffier et al., 2015). Thus, further exploration with additional methodology is warranted, in order to enhance the understanding of these behavioral BID components.

Consequently, we designed a task that confronted patients with EDs with a picture of their own body (self-picture) and compared it to a weight matched picture of another woman's body (other-picture). We focused on picture-based approach behavior as we reasoned this to be a laboratory analog for self-confrontation with regard to mirror exposures. Self-pictures might elicit the experience of negative emotions (e.g., disgust or shame) and thus less of an approach to the pictures, maybe particularly in individuals with BA. A different pattern is predicted under the BC perspective: a precise inspection of the picture (zooming in and increasing focus), potentially motivated by the desire to engage in safety behavior, e.g., looking at certain points of the body to reduce the negative feelings. Given that BID, in particular the behavioral components are best investigated and probably most prominent in the classical EDs such as AN and BN, we recruited a mixed ED sample with patients diagnosed with either AN or BN. This mixed ED group was contrasted against matched healthy controls. However, as findings on differences between AN and BN regarding BC and BA or body dissatisfaction and picture ratings have been inconsistent (Legenbauer et al., 2007, 2017), we also explored differences between these two groups in a second set of analyses. Participants underwent the above described task alongside picture-based attractiveness/satisfaction ratings and established psychometric measures of BA and BC.

We assumed that both AN and BN patients would evaluate their own body as less attractive and report higher dissatisfaction with their own body compared to healthy controls. Consequently, we assumed that AN and BN patients would show stronger avoidance of self-pictures compared to other-pictures. In contrast, healthy controls might inspect their own body more closely (i.e., higher zoom-levels) than other-pictures. In addition, we expected opposing correlational patterns for BA and BC. Finally, we hypothesized that self-reported behavioral BA and BC levels predict zoom-level.

MATERIALS AND METHODS

Participants

The study represented an exploratory extension of a study program on body image in AN and BN sponsored by the German Research Foundation (Tuschen-Caffier and Ansorge; TU 78/6-1.). The present sample consisted of 40 women diagnosed with an eating disorder (ED; 19 with BN, 21 with AN), and 24 healthy female controls (HC). Groups were matched on age and education on the group level. Schizophrenia spectrum disorders, bipolar disorder, substance abuse or dependence and neurological disorders served as exclusion criteria for the ED group, any lifetime mental disorder according to DSM-IV for the HC group. The German version of the Eating Disorder Examination (EDE, Hilbert and Tuschen-Caffier, 2006) and the Structured Clinical Interview for DSM-IV (SCID, Wittchen et al., 1997) were used to diagnose EDs, as well as other psychiatric disorders, respectively. The following comorbid disorders were found in the ED group (BN/AN): major depression ($N = 8/N = 5$), dysthymia ($N = 3/N = 1$), borderline personality disorder ($N = 4/N = 2$), posttraumatic stress disorder ($N = 4/N = 1$), social phobia ($N = 2/N = 1$), obsessive-compulsive disorder ($N = 1/N = 0$), and panic disorder with agoraphobia ($N = 1/N = 0$). Five BN patients reported a history of AN.

Clinical Interviews

Eating Disorder Examination (EDE)

The German version of the EDE (Hilbert and Tuschen-Caffier, 2006) was administered. The EDE is a semi-structured interview assessing ED specific symptoms that have occurred within the previous 28 days. Amount and frequency of these characteristics are assessed. Scores can be calculated for four subscales: "eating concern," "weight concern," "shape concern," and "restraint." It assesses further relevant characteristics of eating disordered behaviors and attitudes with 14 single items. The German version provides good internal consistencies for the subscales ($\alpha = 0.73$–0.86) and the total score ($\alpha = 0.93$). Interrater reliability (r) for items ranges from 0.80 to 1.00, and for the subscales ($r = 0.92$–0.99).

Structural Clinical Interview for DSM-IV TR Axis I Disorders (SCID I)

The SCID I (SCID I; First et al., 1996; German version: Wittchen et al., 1997) is a semi-structured interview for making DSM-IV axis I diagnoses. Its validity has been shown in many studies.

Self-Report Measures

Eating Disorder Examination Questionnaire (EDE-Q)

The EDE-Q (Fairburn and Beglin, 1994) assesses the degree of eating disturbances and BID for the past 28 days across the following four dimensions: "restraint eating," "eating concerns," "weight concerns," and "shape concern." The German version of the EDE-Q (Hilbert et al., 2007) shows good convergent and discriminatory validity, a high reliability and retest-reliability (Hilbert et al., 2012).

Body Image Avoidance Questionnaire (BIAQ)

The BIAQ is used to measure self-reported body related avoidance behavior (Rosen et al., 1991). Whereas the English original version consists of 19 items and 4 subscales, the German translation (Legenbauer et al., 2007) revealed three factors "clothing," "social activity," and "eating restraint" based on 11 items. Its internal consistency has been proven to be acceptable (Cronbach's $\alpha = 0.64$–0.76; present sample: Cronbach's $\alpha = 0.85$) and showed moderately stable test–retest reliability ($r_{tt} = 0.64$, $p < 0.001$–0.81, $p < 0.001$). To reduce codependency between body image avoidance and body checking, we decided to exclude the "eating restraint" factor (Cronbach's $\alpha = 0.79$) from our analyses, as it assesses also behavior that reflects control of food intake and not solely body related avoidance behavior.

Body Checking Questionnaire (BCQ)

The BCQ assesses the degree of self-reported body checking behavior and body focused control strategies (Reas et al., 2002). Its 23 items load on three separate factors: "overall appearance," "specific body parts," and "idiosyncratic checking." An example item is "I check to see how my bottom looks in the mirror." Good internal consistency (Cronbach's $\alpha = 0.83$–0.92) and test–retest-reliability have been demonstrated ($r_{tt} = 0.90$, $p < 0.001$; Reas et al., 2002). The German version, by contrast, reveals a single factor (Vocks et al., 2008). It also shows good internal consistency (Cronbach's $\alpha = 0.83$–0.95; present sample: Cronbach's $\alpha = 0.96$).

Procedure

Diagnostic Assessment

Participants took part in exchange for €50 and were recruited from the community through newspaper announcements, our website, and from collaborating clinics. After a telephone screening, eligible participants were invited to a diagnostic session during which the EDE and SCID interviews were conducted.

Photo Shooting Session and Image Generation

Right after diagnostic assessment, photographs were taken and BMI determined. Participants were asked to put on a beige leotard and to stand in front of a black background. Digital pictures (termed self-picture in the following) were taken by a female experimenter from frontal, side and back view, excluding the head. The self-picture was compared to a single comparison body which was a picture taken from another participant of the same study (other-picture) that was approximately equated for BMI (± 1.5 kg/m^2). Colored body pictures were matched by eye in size and luminance[1].

Each of the three views were zoomed and blurred at the same time in 13 different levels (see **Figure 1**) presenting the highest blur first, ending with a fully focused high-resolution picture. Thus, the focused picture could then be zoomed closer another

[1] Images were not compared on any algorithmically derived index as it is not clear which parameter (e.g., edge detection, spectral complexity, contrast, brightness, and color composition) would be relevant. However, to prevent any gross differences, the last author individually edited the photos to make them as similar as possible, e.g., in color saturation or size.

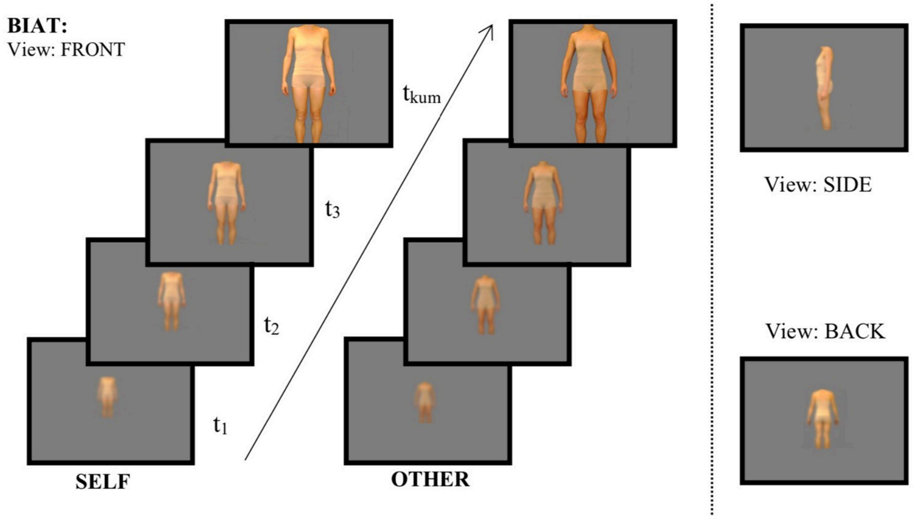

FIGURE 1 | Procedure of the Body Image Approach Test (BIAT). Participants moved from low to high zoom level (increasing picture size and reducing the blurredness) by using the right mouse button. Time (t) as well as zoom level were captured for each picture. BIAT = Body Image Approach Task, FRONT = pictures presenting the front image of the participant, SIDE = pictures presenting the view on the body from the side, BACK = pictures presenting the view of the backside of the body. SELF = pictures of the own body, OTHER = pictures from bodies of weight matched control females.

11 times, so in total 24 zoom levels were possible (until maximal image extension on the 21-inch monitor).

Experiment

The Body Image Approach Task (BIAT) was introduced as follows: *"In the following you will be asked to evaluate pictures of yourself and of another person. But first you can look at them (front, side, back view). You can increase their size and improve the focus by pressing the right mouse button. Switch to the next slide using the middle button."* The experimenter emphasized that participants were free to explore the pictures at their own pace, and then left the laboratory to reduce potential experimenter effects. Photos were then shown in the fixed order "self-front," "other-front," "self-side," "other-side," "self-back," "other-back" along with the corresponding label "self" or "other" (to obviate the need for identification). The participant could advance to the next picture by clicking the middle mouse button. Image width/height was locked on all zoom levels, avoiding disproportional distortion. Viewing times and final zoom-level for each view (front, side, back view) and person (self-picture, other-picture) were registered. However, preliminary analyses indicated that viewing time did not reveal any effect that were not captured by zoom-level, too, and analyses of viewing times were therefore dropped for brevity. Final zoom-level (ranging from 1 for the initial, most remote zoom-level to 24 for maximal zoom) assessed the degree to which participants approached the pictures. In a subsequent step the same images were rated on a scale of -10 to 10 for attractiveness ("unattractive" – "attractive") and satisfaction ("not pleased" – "pleased"). Image ratings of a subset of participants were published previously (Blechert et al., 2010). After BIAT and image ratings, several other tasks followed, assessing attentional biases regarding the images (Blechert et al., 2010). On a separate test day, several other tasks were completed by a subset of participants of the present sample (Blechert et al., 2011a,b).

Statistical Analysis

Prior to analysis, the data was screened for potential outliers and missing data. Little's MCAR test (Little, 1988) revealed that the data was missing completely at random ($p > 0.999$). Hence, mean imputation was used to deal with missing data. Outliers were defined as values exceeding 3.29 standard deviations above or below the mean (Tabachnick and Fidell, 2001). Accordingly, one participant had to be excluded due to unreasonably high viewing times across the different zoom-levels. Moreover, one participant had to be excluded due to technical difficulties, leaving a final sample of 62 participants. The α-criterion was set to 0.05 for all analyses. To assess differences in approach tendencies between ED and HC repeated measures analysis of variance (ANOVA) was performed. Here, a mixed model design was employed with Group (ED vs. HC) as between-subjects factor and Picture Type (self vs. other), as well as Picture Angle (front, side, back) as within-subject factors. Zoom-level served as dependent measure. In addition, two repeated measures ANOVAs with attractiveness ratings and body satisfaction as independent variables and Group (ED vs. HC) and Picture Type (self vs. other) were calculated to explore associations with other BID areas. All analyses were also performed with a 3-level group factor (AN, BN, HC). Pearson correlations assessed associations between approach behavior and specific ED behavior as well as general level of ED symptomatology for each group separately by relating total zoom-level for self- and other-pictures to the degree of BC and BA. Last, to test for the relative influence of overall ED symptomatology, BA and BC behavior as well as picture attractiveness and satisfaction ratings on BIAT zoom-level, we conducted a stepwise multiple regression. We entered ED symptom level at the first step (EDE-Q sum score), self-reported BA and BC at the second step and evaluation of the self-pictures as attractive and satisfying at the third step.

RESULTS

Participant Characteristics

As indicated in **Table 1**, HC and ED did not differ in terms of age or BMI. However, women with ED had fewer years of education, engaged more frequently in BC, showed greater BA and higher ED psychopathology. There were no differences between AN and BN regarding these variables with the exception of BMI ($p < 0.001$). Therefore, only the results of the ANOVA with ED vs. HC as group factor are reported for reasons of brevity. Details regarding differences between AN and BN are provided as **Supplementary Tables S1–S3**. Furthermore, instead of full reporting, only crucial effects, mostly the interactions with Group, will be reported.

Body Image Approach Task

Zoom-Level

Both groups zoomed in more toward self-pictures compared to other-pictures ($M_{self} = 12.55$, $SE = 0.72$; $M_{other} = 11.86$, $SE = 0.66$; $F(1,60) = 5.819$, $p = 0.019$, $\eta_p^2 = 0.088$). None of the effects involving Group reached significance (all Fs < 2.00; ps > 0.125). **Table 2** presents mean scores and standard deviations for zoom-level separated for Picture Type and Group.

TABLE 2 | Final zoom level scores separated by groups, picture type and angle.

	ED (*N* = 39)		HC (*N* = 23)	
	M	***SD***	***M***	***SD***
self-pictures total	11.92	5.37	13.19	5.45
Front	12.15	6.78	13.17	5.89
Side	11.59	5.08	13.09	6.34
Back	12.00	5.43	13.30	5.83
other-pictures total	11.56	4.74	12.15	4.99
Front	11.08	4.89	11.48	5.82
Side	12.41	5.26	12.04	5.51
Back	11.21	5.33	12.91	5.59

Final zoom level corresponds to the last picture. self-pictures = pictures of the own body, other-pictures = pictures of another women's body (BMI matched). ED, eating disorder sample; HC, healthy female controls; M = mean, SD = standard deviation.

Subjective Image Ratings

Attractiveness

A significant interaction between Picture Type ∗ Group was found ($F(1,60) = 20.003$, $p < 0.001$, $\eta_p^2 = 0.250$). *Post hoc* independent t-tests revealed that participants with an ED rated self-pictures less attractive compared to HC ($t(60) = -8.828$, $p < 0.001$, see **Figure 1**), whereas no group differences were found for other-pictures ($t(60) = -1.736$; $p = 0.088$). Paired samples t-tests highlighted the differences in picture ratings within each group. ED patients rated self-pictures less attractive compared to other-pictures ($t(38) = -4.900$, $p < 0.001$; $M_{other} = -0.68$, $SD = 4.33$). By contrast, HC's rated self-pictures as much more attractive than other-pictures ($t(22) = 2.124$, $p = 0.045$; $M_{other} = 1.25$, $SD = 4.00$). Also, a main effect for Picture Type emerged ($F(1,60) = 4.753$, $p = 0.033$, $\eta_p^2 = 0.073$) with self-pictures being overall rated more attractive than other-pictures ($M_{self} = -0.995$, $SE = 0.498$; $M_{other} = 0.576$, $SE = 0.557$). Means and standard deviations are displayed in **Figure 2**.

Satisfaction

A significant interaction emerged between Picture Type ∗ Group ($F(1,60) = 20.001$, $p < 0.001$). ED patients were less satisfied with their self-pictures compared to HC's ($t(60) = -9.155$, $p < 0.001$). The same pattern applied for other-pictures ($t(60) = -2.400$, $p = 0.020$; $M_{ED} = -0.76$, $SD = 4.28$; $M_{HC} = 1.91$, $SD = 4.16$). While comparing satisfaction ratings for self- and other-pictures within one group, it became apparent that participants with EDs were much less satisfied with their self-pictures compared to pictures from others ($t(38) = -4.703$, $p < 0.001$; $M_{self} = -5.56$, $SD = 3.89$; $M_{other} = -0.76$, $SD = 4.28$). HC's on the other hand, were much more satisfied with their self-picture compared to

TABLE 1 | Sample characteristics.

	ED (*N* = 39)		HC (*N* = 23)		Statistics		
	M	***SD***	***M***	***SD***	***F***	***p***	***d***
Age (in years)	24.90	6.6	26.70	4.65	3.247	0.256	–
Education (years)	11.67	1.74	12.87	0.63	66.9	<0.01	1.01
BMI	19.19	3.66	20.29	2.21	5.368	0.199	–
BIAQ (sum)[#]	13.92	6.51	4.13	3.56	14.600	<0.001	1.94
Social activities	4.54	3.55	0.48	1.24	44.106	<0.001	1.70
Clothing	9.39	3.71	3.69	2.48	27.981	<0.001	1.84
BCQ	41.76	17.34	11.51	4.68	16.584	<0.001	2.75
EDEQ	4.01	1.26	0.44	0.55	15.084	<0.001	3.94

ED, eating disorder sample; HC, healthy female controls. Final zoom level corresponds to the last picture, BMI, Body Mass Index in kilogram divided by meter square; BIAQ, Body Image Avoidance Questionnaire; BCQ, Body Checking Questionnaire; EDEQ, Eating Disorder Examination Questionnaire. d = effect size according to Cohen's D. #items for eating restraint not included.

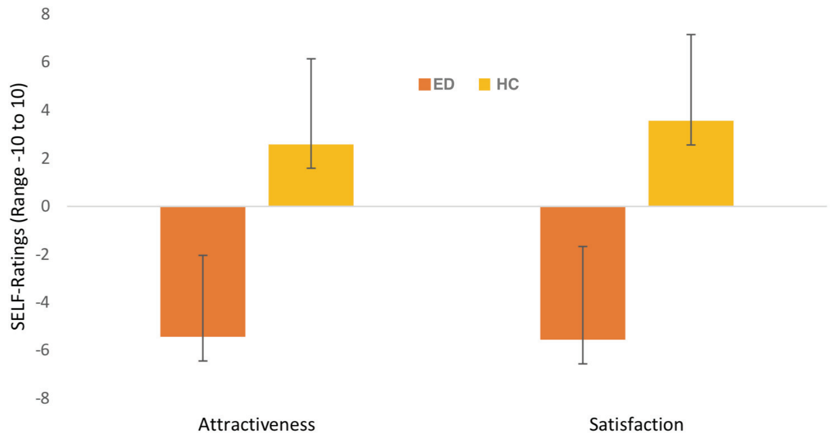

FIGURE 2 | Mean scores and standard deviation for "self-picture" ratings separately for groups. Ratings refer to the dimensions attractiveness, "unattractive" – "attractive"; satisfaction, "not pleased" – "pleased"; (*x*-axis) with a range from -10 to 10 (*y*-axis). ED = eating disorder sample, HC = healthy female controls.

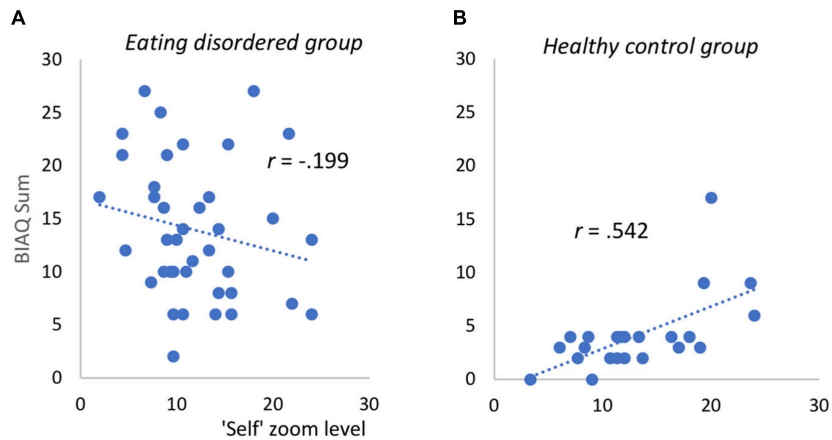

FIGURE 3 | Scatterplots for association between "self"-picture zoom level and body image avoidance in eating disordered patients **(A)** and healthy controls **(B)**. Correlation remains significant after deleting one outlier on BIAQ (value of 17, healthy control group). BIAQ = Body Image Avoidance Questionnaire, computed without items for eating restraint (see text).

other-pictures ($t(22) = 2.291$, $p = 0.032$; $M_{self} = 3.57$, $SD = 3.60$; $M_{other} = 1.91$, $SD = 4.16$). In addition, a significant interaction was found for Picture Angle ∗ Group ($F(2,120) = 3.67$, $p < 0.05$). *Post hoc* independent *t*-tests demonstrated that participants with an ED were less satisfied with pictures taken from all angles compared to HC's (all *p*'s < 0.001). Furthermore, *post hoc* paired samples *t*-tests revealed that the different photo perspectives did not influence the satisfaction ratings for participants with EDs (all *p*'s > 0.405). HCs were more satisfied when seeing front pictures compared to backside pictures ($t(22) = -2.77$, $p < 0.05$; $M_{FrontAngle} = 3.46$, $SD = 3.85$; $M_{BackAngle} = 1.78$, $SD = 4.02$).

Associations Between BIAT Zoom-Level and ED Specific and General Symptoms

For patients with an ED, no significant associations between the zoom-level and BC nor the degree of BA as well as ED features and general psychopathology emerged. In HC, by contrast, BA was positively associated with the degree of zooming into self- and other-pictures ($r(23)_{self} = 0.623$, $p < 0.001$ see **Figure 3**; $r(23)_{other} = 0.542$, $p = 0.008$). The degree of zooming was not associated with the degree of BC (*r*'s < 0.3, *p*'s > 0.12). Also, for other-pictures, no further significant correlations emerged (see **Supplementary Table S4**). For self-pictures, the attractiveness ratings as well as the satisfaction ratings were significantly associated with zoom-level among HC. Also, level of ED symptomatology captured with the EDEQ total score was significantly correlated with final zoom-level among HC. For further details please see **Table 3**.

Prediction of Zoom-Level

The stepwise hierarchical regression model was not significant for ED patients and therefore is only reported within the **Supplementary Table S5**. In contrast, the model for the HC group revealed statistically significant improvements in each step. The variables entered in the first step (EDE-Q mean

TABLE 3 | Correlation coefficients for "self-pictures" in the BIAT with eating disorder and body image disturbance symptomatology among healthy controls (upper diagonal) and eating disorder patients (lower diagonal).

		Zoom	Satisfaction	Attractiveness	EDEQ	BCQ	BIAQ
Zoom	r	1	**−0.540**	**−0.704**	**0.460**	0.330	**0.623**
	p		**0.008**	**<0.001**	**0.027**	0.124	**0.001**
Satisfaction	r	0.094	1	**0.828**	**−0.489**	**−0.567**	−0.371
	p	0.567		**<0.001**	**0.018**	**0.005**	0.081
Attractiveness	r	0.041	**0.848**	1	**−0.469**	**−0.642**	**−0.469**
	p	0.802	**0.000**		**0.024**	**0.001**	**0.024**
EDEQ	r	−0.100	**−0.467**	**−0.317**	1	0.389	**0.486**
	p	0.545	**0.033**	**0.049**		0.067	**0.019**
BCQ	r	−0.041	−0.299	**−0.320**	**0.631**	1	0.224
	p	0.806	0.065	**0.047**	**<0.001**		0.304
BIAQ	r	−0.199	**−0.319**	−0.207	**0.567**	0.271	1
	p	0.226	**0.048**	0.207	**<0.001**	0.095	

Zoom = final zoom level during the body image avoidance task (BIAT); Satisfaction = satisfaction ratings for self-pictures, Attractiveness = attractiveness ratings for self-pictures, EDEQ = Eating Disorder Examination Questionnaire total score, BCQ = Body Checking Questionnaire, BIAQ = Body Image Avoidance Questionnaire, sum score without eating restraint items; r = pearson correlation coefficient, p = probability level. Bold letters indicate statistical significance. Gray colored numbers in the lower diagonal display coefficients among ED patients, black colored numbers in the upper diagonal represents coefficients among healthy controls.

TABLE 4 | Results of stepwise hierarchical regression analyses with zoom level as dependent variable (HC group).

		B	SE	Beta	*T*	*p*
1	(constant)	11.137	1.370		8.132	0.000
	EDEQ	4.698	1.981	0.460	2.371	0.027
2	(Constant)	7.007	2.656		2.638	0.016
	EDEQ	1.512	2.123	0.148	0.712	0.485
	BA	0.812	0.309	0.516	2.627	0.017
	BC	0.188	0.223	0.157	0.845	0.409
3	(Constant)	16.958	4.138		4.098	0.001
	EDEQ	0.933	1.894	0.091	0.845	0.409
	BA	0.510	0.286	0.324	1.786	0.092
	BC	−0.204	0.236	−0.170	−0.864	0.637
	Satis	0.202	0.421	0.130	0.480	0.637
	Attr	−1.143	0.473	−0.726	−2.413	0.027

Zoom = final zoom level during the body image avoidance task (BIAT); EDE = Eating Disorder Examination questionnaire total score, BC = sum score of the Body Checking Questionnaire, BA = sum score without control eating items of the Body Image Avoidance Questionnaire, Satis = satisfaction ratings for SELF-pictures, Attr = attractiveness ratings for SELF-pictures, B = standardized Beta, SE = Standard error, beta = unweight Beta.

score) explained 17.4% of zoom-level variance ($F(1,21) = 5.622$, $p = 0.027$) indicating a positive significant influence of ED symptomatology on final zoom-level in the BIAT. Entering self-reported levels of BA and BC increased the explained variance significantly ($p = 0.038$) and led to 35.3% of total explained variance ($F(3,19) = 5.002$, $p = 0.010$). At this step, EDE-Q sum score lost its significance and BA emerged as single significant predictor of zoom-level. BC was not of relevance. When entering the self-picture ratings in the third step ($F(5,22) = 5.763$, $p = 0.003$) explained variance increased to 52.0%. In this third step, only attractiveness ratings emerged as significant predictor. The details for this regression model are displayed in **Table 4**.

DISCUSSION

The present study is the first to apply a behavioral approach task to assess BA and BC in women with a diagnosed ED in regard to images of their own body (and a matched control body). Thus, it represents an important step beyond self-report and can therefore enhance our understanding of this neglected behavioral BID component. The results can be summarized as follows: First, our picture ratings on attractiveness and satisfaction replicated previous findings of a strongly negative cognitive affective BID in both AN and BN – both ED groups rated their self-picture much more negative as the BMI-matched other picture, with the reverse being true in healthy controls. Despite these robust group differences, the same patients did not approach their self-pictures differentially in the picture zooming procedure of the BIAT. Furthermore, the questionnaire measures of BID, the BCQ and the BIAQ did not correlate with the new BIAT in the ED sample. Only in HCs did the BIAT correlate strongly and positively with self-reported BA, suggesting initial evidence for construct validity with regard to the lower levels of body image avoidance scores of healthy controls. Considering associations between BA, ED symptom level and body satisfaction, the regression analyses within the healthy control group revealed that ratings of perceived attractiveness of the own body was the most relevant predictor of approach behavior as measured in the BIAT. This underlines the critical role of body related attitudes also for behavioral features in non-eating disordered women.

These results raise several questions: First, the BIAT did not differentiate between ED and HC and as such did not complement findings from studies using AAT to capture approach-avoidance behavior as a behavioral assessment. Given that the BIAT seems a valid tool in assessing disorder specific psychopathology in various psychiatric conditions, in particular anxiety (Deacon and Olatunji, 2007; Olatunji et al., 2007; Brady and Lohr, 2014) the question as to why ED patients do not respond to their own, disliked self-images in a similar way as phobic patients to disorder specific stimuli (e.g., spiders) is puzzling. It is possible that the focus on approach behavior – namely the start with the most blurred and small picture size going to the highest solution and biggest size – is not as sensitive in highly pathological samples as the AAT design which allows participants to "move" pictures away or toward oneself and which focusses on reaction times. On the other hand, the only study that applied an AAT in (questionnaire-defined) patients with eating disturbances and BID (Leins et al., 2018) did not include self-images and it is therefore not easy to compare the two studies. Interestingly, Leins et al. (2018) also failed to replicate an approach bias toward thin pictures, illustrating how difficult it generally is to reliably capture approach-avoidance behavior toward body images. This might also be caused by their use of computer-generated bodily stimuli (avatars; e.g., Woud et al., 2011; Leins et al., 2018; Dondzilo et al., 2019). We tried to overcome this limitation by using self-pictures compared to other-pictures, however, this did not lead to a more differential pattern between groups. It is possible that pictures of one's own body without head displayed on a computer screen did not elicit strong enough automatic approach or avoidance or body-related anxiety. However, looking at the ratings for self- and other-pictures, it is obvious that the negative attitude concerning the own body had been elicited in ED patients, as these reported significantly more negative attitudes toward their own body compared to the bodies of other females. Also, EDs showed significantly stronger negative attitudes compared to HCs. This is in line with former research showing implicit negative body-related attitudes in women with AN and BN compared to healthy women (e.g., Voges et al., 2018).

A further point that is puzzling is that self-report assessments neither for BA nor for BC in ED patients correlated with the results in the BIAT. Former research indicates that BC and BA serve different functions implying alternated representations depending on situational contexts (e.g., Shafran et al., 2004; Bailey and Waller, 2017; Radix et al., 2018). BC includes primarily repetitive actions to check one's shape and weight (e.g., weighing, pinching in the skin, examining body parts in the mirror or seeking reassurance from others), whereas BA comprises actions that hinder the confrontation with one's shape and weight. Recent evidence emphasizes the role of social context for BA and BC by pointing out that social anxieties and fear of negative evaluation in patients with various EDs serve as a potential mediator between ED symptomatology and BC and BA behavior (Radix et al., 2018). As such, it might be that the lack of social context and the rather "artificial" pictures without head presented during the BIAT rather triggered BA instead of BC. The impact of social context and social comparison might also account for a lack of associations between BA and BIAT zoom-levels in the ED sample; it might be that AN and BN patients are more used to look at their own bodies and that social context and fear of evaluation is necessary to trigger compensatory safety behaviors (e.g., Utschig et al., 2010), whereas in healthy female controls looking at pictures of the own body is not that usual and therefore triggers body dissatisfaction which is associated with BA. Thus, the approach behavior as assessed with the BIAT might tap into a different function that is not presented in highly pathological avoiders and thus does not detect differential effects in this group.

Interestingly, in the HC group, higher avoidance in the BIAQ (our measure of BA) went along with higher zoom-levels for self- as well as other-pictures in the BIAT. This dovetails with the perplexing finding that some individuals report *both* body-related avoidance behavior on the BIAQ *and* frequent body checking (as evident from a positive correlation of both instruments in other samples (e.g., Campana et al., 2013; Legenbauer et al., 2017; Radix et al., 2018; and the present sample). We verified that control females were healthy via a structured clinical interview, nevertheless there seemed to be some behavioral body related avoidance or checking. Hence, on subclinical levels, one could think of this pattern as some kind of ambivalent situation, being dissatisfied and still vigilant to it. Thus, it seems that there were at least some individuals in the HC group reporting some BA behavior and this is expressed in lower BIAT zoom-levels. An even better measure of BA, however, seems to be the image attractiveness ratings: when taking these into account, BIAQ scores no longer predict zoom-level. This is in contrast to former results that emphasized the influence of body dissatisfaction and drive for thinness. In the present analyses, self-rated attractiveness was the most powerful predictor pointing toward a dominant role of the thin ideal and body related attitudes on approach behavior. Theories of social comparison point out that most information is gained from comparing against similar others, so this might have taken place here (Goethals and Darley, 1977).

Besides the strength of a clinical sample diagnosed with a clinical structured interview and the thoroughly performed assessment, there are some limitations that have to be mentioned. *First*, the present study includes various ED categories which might have conflated differential effects for single ED categories. We controlled for such differential effects between AN and BN patients, but failed to find any in relation to BA, BC or BIAT or sample characteristics. It may be that the ED subsamples were too small to detect smaller effects. Small sample size also affects the correlational analysis within the HC group and calls for replication in a larger sample. *Second*, it might also be that methodological issues of the BA self-report tool account for the lack of associations in ED. We used the BIAQ that has been developed in student samples and whose original structure has not been replicated in several studies (Legenbauer et al., 2007; Campana et al., 2013; Brytek-Matera and Rogoza, 2016). It has to be considered that within the German version, the original factor structure had not been replicated and that items in relation to eating loaded on a factor that reflects rather control than avoidance (Legenbauer et al., 2007). To minimize possible dependencies between BA and BC self-report, we did not include the eating control items in the sum score. Thus, the items of the BIAQ used in the analyses relate to clothing and social activities. These are behaviors that might reflect other components of avoidance behavior than those captured within the BIAT. Also, it is possible that the self-report assessments do not adequately capture the behavioral symptoms such as body checking and body image avoidance behaviors, thus veiling any relationship with the BIAT. *Third*, and related to the validity of the BIAT task, avoidance behavior might not be well captured, because the BIAT does not explicitly include the possibility to push the picture away (as possible in a classical joystick-AAT). Yet, participants were free to use the middle mouse button to advance immediately to the next photo. Similarly, we cannot be sure that zooming in and increasing focus in the BIAT corresponds to naturalistic body related checking behaviors even though it corresponds well to the classical bodily inspection in a mirror. *Fourth*, while we chose one single "other" body per participant and made sure that it matches the participant's BMI $\pm$1.5 kg/m^2) we did not use a different "other" body for each participant. Thus, variance in the "other" category might be restricted. *Finally*, by displaying the whole body, differences regarding different body parts could not be taken into account which awaits future study.

CONCLUSION

The present study represents a first step toward an assessment tool for the behavioral component of body image. So far, it seems that what is measured by the current BA questionnaire in healthy individuals goes along with more detailed checking and close examination of body related pictures of ones' own body, maybe in search for signs of failures or deviations and a similar examination of relevant comparison bodies (other's bodies). At higher levels of BA – as here in the ED patient group – this relationship is lost or countered by additional processes that we could not measure here. In other words, the BIAT does not seem to capture the body image satisfaction or the behavioral components of BID in ED patients or it conflates counteracting influences such as BA and BC. Further experimentation is needed to adapt measures of behavioral body image components to the processes engaged in patients with ED during confrontation with body images. Inclusion of social context information and mood (anxiety) or stress induction may be a next step to enhance the understanding of the behavioral BID component in EDs.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The study was approved by the ethics committee of the German Society for Psychology. The study protocol was conducted in accordance with the Declaration of Helsinki (revised 1983). Written informed consent was provided by all participants, who were aware that they could withdraw from the experiment at any time without further consequences.

AUTHOR CONTRIBUTIONS

JB designed the study, collected the data, and participated in the analyses and manuscript writing. EN, AR, and TL analyzed the data. TL and AR conducted the literature review and wrote the first draft of the manuscript. All authors approved the final version of the manuscript.

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SUPPLEMENTARY MATERIAL

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REFERENCES

American Psychiatric Association [APA] (2013). *Diagnostic and Statistical Manual of Mental Disorders*, 5th Edn. Washington, DC: American Psychiatric Association Press, doi: 10.1176/appi.books.9780890425596

Bailey, N., and Waller, G. (2017). Body checking in non-clinical women: experimental evidence of a specific impact on fear of uncontrollable weight gain. *Int. J. Eat. Disord.* 50, 693–697. doi: 10.1002/eat.22676

Bamford, B. H., Attoe, C., Mountford, V. A., Morgan, J. F., and Sly, R. (2014). Body checking and avoidance in low weight and weight restored individuals with anorexia nervosa and non-clinical females. *Eat. Behav.* 15, 5–8. doi: 10.1016/j.eatbeh.2013.10.011

Blechert, J., Ansorge, U., Beckmann, S., and Tuschen-Caffier, B. (2011a). The undue influence of shape and weight on self-evaluation in anorexia nervosa, bulimia nervosa and restrained eaters: a combined ERP and behavioral study. *Psychol. Med.* 41, 185–194. doi: 10.1017/S0033291710000395

Blechert, J., Ansorge, U., and Tuschen-Caffier, B. (2010). A body-related dot-probe task reveals distinct attentional patterns for bulimia nervosa and anorexia nervosa. *J. Abnorm. Psychol.* 119, 575. doi: 10.1037/a0019531

Blechert, J., Feige, B., Joos, A., Zeeck, A., and Tuschen-Caffier, B. (2011b). Electrocortical processing of food and emotional pictures in anorexia nervosa and bulimia nervosa. *Psychosom. Med.* 73, 415–421. doi: 10.1097/PSY.0b013e318211b871

Brady, R. E., and Lohr, J. M. (2014). A behavioral test of contamination fear in excessive health anxiety. *J. Behav. Ther. Exp. Psychiatry* 45, 122–127. doi: 10.1016/j.jbtep.2013.09.011

Brytek-Matera, A., and Rogoza, R. (2016). The polish version of the body image avoidance questionnaire: an exploratory structural equation modeling approach. *Eat. Weight Disord.* 21, 65–72. doi: 10.1007/s40519-015-0206-z

Campana, A. N., Swami, V., Onodera, C. M., da Silva, D., and Tavares, M. (2013). An initial psychometric evaluation and exploratory cross-sectional study of the body checking questionnaire among Brazilian women. *PLoS One* 8:e74649. doi: 10.1371/journal.pone.0074649

Cash, T. F., and Deagle, E. A. III (1997). The nature and extent of body-image disturbance in anorexia and bulimia nervosa: a meta-analysis. *Int. J. Eat. Disord.* 22, 107–241.

Deacon, B., and Olatunji, B. O. (2007). Specificity of disgust sensitivity in the prediction of behavioral avoidance in contamination fear. *Behav. Res. Ther.* 45:2110e2120.

Dondzilo, L., Rieger, E., Jayawardena, N., and Bell, J. (2019). Drive for thinness versus fear of fat: approach and avoidance motivation regarding thin and non-thin images in women. *Cogn. Ther. Res.* 43, 585–593. doi: 10.1007/s10608-018-9989-3

Fairburn, C. G., and Beglin, S. J. (1994). Assessment of eating disorders: interview or self-report questionnaire? *Int. J. Eat. Disord.* 16, 363–370.

Fairburn, C. G., Cooper, Z., and Shafran, R. (2003). Cognitive behavior therapy for eating disorders: a "transdiagnostic" theory and treatment. *Behav. Res. Ther.* 41, 509–528. doi: 10.1016/S0005-7967(02)00088-8

First, M. B., Gibbon, M., Spitzer, R. L., and Williams, J. B. W. (1996). *User's Guide for the Structured Clinical Interview for DSM-IV axis I Disorders—Research Version*. New York, NY: New York State Psychiatric Institute.

Goethals, G. R., and Darley, J. (1977). "Social comparison theory: an attributional approach," in *Social comparison processes: Theoretical and empirical perspectives*, eds J. M. Suls, and R. L. Miller, (Washington,DC: Hemisphere), 259–278.

Hilbert, A., de Zwaan, M., and Braehler, E. (2012). How frequent are eating disturbances in the population? Norms of the eating disorder examination-questionnaire. *PLoS One* 7:e29125. doi: 10.1371/journal.pone.0029125

Hilbert, A., and Tuschen-Caffier, B. (2006). *Eating Disorder Examination: Deutschsprachige Übersetzung*. Münster: Verlag für Psychotherapie.

Hilbert, A., Tuschen-Caffier, B., Karwautz, A., Niederhofer, H., and Munsch, S. (2007). Eating Disorder Examination-questionnaire: evaluation der deutschsprachigen Übersetzung. *Diagnostica* 53, 144–154.

Jansen, A., Nederkoorn, C., and Mulkens, S. (2005). Selective visual attention for ugly and beautiful body parts in eating disorders. *Behav. Res. Ther.* 43, 183–196. doi: 10.1016/j.brat.2004.01.003

Jansen, A., Smeets, T., Martijn, C., and Nederkoorn, C. (2006). I see what you see: the lack of a self-serving body-image bias in eating disorders. *Br. J. Clin. Psychol.* 45, 123–135. doi: 10.1348/014466505x50167

Legenbauer, T., Martin, F., Blaschke, A., Schwenzfeier, A., Blechert, J., and Schnicker, K. (2017). Two sides of the same coin? A new instrument to assess body checking and avoidance behaviors in eating disorders. *Body Image* 21, 39–46. doi: 10.1016/j.bodyim.2017.02.004

Legenbauer, T., Thiemann, P., and Vocks, S. (2013). Body image disturbance in children and adolescents with eating disorders. *Z. Kinder. Jugendpsychiatr. Psychother.* 42, 51–59. doi: 10.1024/1422-4917/a000269

Legenbauer, T., Vocks, S., and Schütt-Strömel, S. (2007). Validierung einer deutschsprachigen Version des Body Image Avoid- ance Questionnaire (BIAQ) [Validation of the German version of the Body Image Avoidance Questionnaire]. *Diagnostica* 53, 218–225. doi: 10.1026/0012-1924.53.4.218

Leins, J., Waldorf, M., Kollei, I., Rinck, M., and Steins-Loeber, S. (2018). Approach and avoidance: relations with the thin body ideal in women with disordered eating behavior. *Psychiatry Res.* 269, 286–292. doi: 10.1016/j.psychres.2018.08.029

Little, R. J. (1988). A test of missing completely at random for multivariate data with missing values. *J. Am. Stat. Assoc.* 83, 1198–1202. doi: 10.1080/01621459.1988.10478722

Mond, J. M., Hay, P. J., Rodgers, B., Owen, C., and Beumont, P. J. V. (2004). Validity of the Eating Disorder Examination Questionnaire (EDE-Q) in screening for eating disorders in community samples. *Behav. Res. Ther.* 42, 551–567. doi: 10.1016/s0005-7967(03)00161-x

Mountford, V., Haase, A., and Waller, G. (2006). Body checking in the eating disorders: associations between cognitions and behaviors. *Int. J. Eat. Disord.* 39, 708–715. doi: 10.1002/eat.20279

Mountford, V., Haase, A. M., and Waller, G. (2007). Is body checking in the eating disorders more closely related to diagnosis or to symptom presentation? *Behav. Res. Ther.* 45, 2704–2711. doi: 10.1016/j.brat.2007.07.008

Olatunji, B. O., Lohr, J. M., Sawchuk, C. N., and Tolin, D. F. (2007). Multimodal assessment of disgust in contamination-related obsessive-compulsive disorder. *Behav. Res. Ther.* 45:263e276.

Radix, A. K., Rinck, M., Becker, E. S., and Legenbauer, T. (2018). The mediating effect of specific social anxiety facets on body checking and avoidance. *Front. Psychol.* 9:2661. doi: 10.3389/fpsyg.2018.02661

Reas, D. L., Whisenhunt, B. L., Netemeyer, R., and Williamson, D. A. (2002). Development of the body checking questionnaire: a self-report measure of body checking behaviors. *Int. J. Eat. Disord.* 31, 324–333. doi: 10.1002/eat.10012

Roefs, A., Jansen, A., Moresi, S., Willems, P., van Grootel, S., and van der Borgh, A. (2008). Looking good. BMI, attractiveness bias and visual attention. *Appetite* 51, 552–555. doi: 10.1016/j.appet.2008.04.008

Rosen, J. C., Srebnik, D., Saltzberg, E., and Wendt, S. (1991). Development of a body image avoidance questionnaire. *J. Consult. Psychol.* 3, 32–37.

Shafran, R., Fairburn, C. G., Robinson, P., and Lask, B. (2004). Body checking and its avoidance in eating disorders. *Int. J. Eat. Disord.* 35, 93–101. doi: 10.1002/eat.10228

Tabachnick, B. G., and Fidell, L. S. (2001). Cleaning up your act: screening data prior to analysis. *J. Multivar. Anal.* 5, 61–116.

Tuschen-Caffier, B., Bender, C., Caffier, D., Klenner, K., Braks, K., and Svaldi, J. (2015). Selective visual attention during mirror exposure in anorexia and bulimia nervosa. *PLoS One* 10:e0145886. doi: 10.1371/journal.pone.0145886

Utschig, A. C., Presnell, K., Madeley, M. C., and Smits, J. A. J. (2010). An investigation of the relationship between fear of negative evaluation and bulimic psychopathology. *Eat. Behav.* 11, 231–238. doi: 10.1016/j.eatbeh.2010.05.003

Vocks, S., Moswald, C., and Legenbauer, T. (2008). Eine deutsch- sprachige Überprüfung des Body Checking Questionnaire (BCQ) [Psychometric analysis of a German version of the Body Checking Questionnaire (BCQ)]. *Z. Klin. Psychol. Psychother.* 37, 131–140.

Voges, M. M., Giabbiconi, C. M., Schöne, B., Braks, K., Huber, T. J., Waldorf, M., et al. (2018). Double standards in body evaluation? How identifying with a body stimulus influences ratings in women with anorexia nervosa and bulimia nervosa. *Int. J. Eat. Disord.* 51, 1223–1232. doi: 10.1002/eat.22967

von Wietersheim, J., Kunzl, F., Hoffmann, H., Glaub, J., Rottler, E., and Traue, H. C. (2012). Selective attention of patients with anorexia nervosa while looking at pictures of their own body and the bodies of others: an exploratory study. *Psychosom. Med.* 74, 107–113. doi: 10.1097/PSY.0b013e31823ba787

Vossbeck-Elsebusch, A. N., Waldorf, M., Legenbauer, T., Bauer, A., Cordes, M., and Vocks, S. (2015). Overestimation of body size in eating disorders and its association to body-related avoidance behavior. *Eat. Weight. Disord.* 20, 173–178. doi: 10.1007/s40519-014-0144-1

Williamson, D. A., White, M. A., York-Crowe, E., and Stewart, T. M. (2004). Cognitive-behavioral theories of eating disorders. *Behav. Mod.* 28, 711–738.

Wittchen, H. U., Zaudig, M., and Fydrich, T. (1997). *SKID. Strukturiertes klinisches Interview für DSM-IV. Achse I und II. Handanweisung*. Göttingen: Hogrefe.

Woud, M. L., Anschutz, D. J., Van Strien, T., and Becker, E. S. (2011). Measuring thinspiration and fear of fat indirectly. A matter of approach and avoidance. *Appetite* 56, 451–455. doi: 10.1016/j.appet.2010.12.012

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ORIGINAL RESEARCH
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Flexible Orientation Tuning of Visual Representations of Human Body Postures: Evidence From Long-Term Priming

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The proficiency of human observers to identify body postures is examined in three experiments. We use a posture decision task in which participants are primed with either anatomically possible or impossible postures (in the latter case the upper and lower body face in opposite directions). In a long-term priming paradigm (i.e., in an initial priming block of trials and a subsequent test phase several minutes later), we manipulate the relation between priming and test postures with respect to the identity of the person in the body postures (Experiment 1), the prototypicality of the depth orientations (Experiment 2), and the variability of the priming orientations (Experiment 3). Reaction time to the test postures is the main dependent variable. In Experiment 1 it is found that priming of postures does not depend on the exact visual appearance of the actor (either same priming and test female or male figure or different figures), supporting the hypothesis that posture priming primarily is determined by the spatial relations between the body parts and much less by characteristics of the person involved. Long-term priming in our paradigm apparently is based on the reactivation of high-level posture representations that make abstraction of the identity of the human figure. In Experiment 2 we observe that privileged or prototypical orientations (e.g., 3/4 views) do not affect long-term priming of body postures. In Experiment 3, we find that increasing or decreasing the variability between the priming and test figures influences reaction time performance. Collectively, these results provide a better understanding of the flexibility (e.g., invariant to identity) and limits (e.g., depending on depth orientation) of the processes supporting human posture recognition.

Keywords: visual perception of body postures, long-term priming, orientation dependence, actor identity, prototypical

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INTRODUCTION

Human observers exhibit an impressive level of proficiency in identifying the body postures of conspecifics (e.g., Daems and Verfaillie, 1999; Rumiati, 2000; Willems et al., 2014 (much like the recognition of faces; e.g., Galton, 1883; Maurer et al., 2002; Van Belle et al., 2010a,b; Verfaillie et al., 2014; Vrancken et al., 2019, although the issue whether face and body recognition are "special" is under debate, e.g., Gauthier et al., 1999; Tai et al., 2004; Reed et al., 2012). On the one hand, this is important from an evolutionary point of view, because posture identification frequently is crucial for adequately interpreting the intention of the interacting partner, which in itself is important for reacting in a socially appropriate manner (e.g., Jellema and Perrett, 2003; Gallese et al., 2004; Sebanz and Frith, 2004; Blake and Shiffrar, 2007; Brooks et al., 2008; Manera et al., 2010, 2011; Brown and Brüne, 2012; Moors et al., 2015; Isik et al., 2017; Vrancken et al., 2017; Wang et al., 2018). On the other hand, the identification of other people's postures is not trivial from a perceptual standpoint (e.g., Gold et al., 2008). Depending on the relation between the acting body and the observer, the same body posture can result in a multitude of possible visual projections (e.g., Verfaillie and Daems, 2002; Chan et al., 2004; de la Rosa et al., 2013; Ballarini and Thornton, 2017). For instance, human observers automatically and effortlessly identify the body postures shown in **Figure 1** as snapshots of a female person running, even though the proximal stimuli are radically different.

In order to investigate the nature of the representations underlying visual perception of human body postures, Daems and Verfaillie (1999), Experiments 3 and 4) developed a posture decision task in combination with a long-term priming procedure. On each trial, in an initial priming block, a static picture of a particular human body posture was shown. In half of the pictures, an anatomically possible pose was presented; in the other half of the trials an anatomically impossible (i.e., the upper-waist body part of the actor was rotated 180° around the top-bottom axis, so that upper and lower body parts were facing in opposite directions; see **Figure 2** for examples) was shown. Participants had to decide whether a posture was anatomically possible or not and reaction time (RT) was registered. After a 5 min break, subjects saw a second, testing, block of anatomically possible and impossible postures (**Figure 3**; we provide more details on the procedure in future sections). Some of the test postures were already presented in the priming block, whereas other postures were new. Daems and Verfaillie (1999) observed a long-term priming effect: In the testing phase, participants were on average about 35 ms faster to decide that a posture was anatomically possible when they had seen the posture before in the priming block than when they encountered the posture for the first time in the testing block.

Daems and Verfaillie (1999; Experiment 4) examined how sharply tuned the representations of a body posture are to a particular orientation in depth. To this end, the depth orientation difference between priming and test posture was varied parametrically. All participants saw exactly the same test postures, but, for a given test posture, a specific participant either saw no related posture in the priming phase or priming and

FIGURE 1 | A snapshot of a running action seen from 4 different viewpoints.

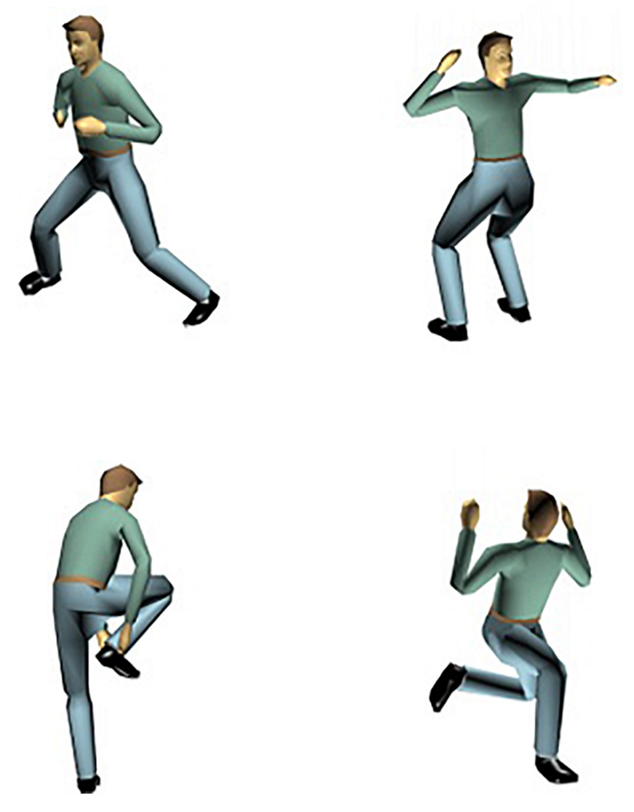

FIGURE 2 | Examples of anatomically possible (first column) and impossible (second column) postures.

primed postures that differed by a 0, 15, 30, 45, or 60° depth rotation around the body's top-bottom axis. For anatomically possible postures, the facilitatory priming effect of about 30 ms was replicated in the same-prime condition (0° difference). In the condition with a depth rotation of only 15°, the priming effect decreased to a (non-significant) 15 ms. After a depth rotation of only 30° or more, the priming effect disappeared completely. This finding suggests that visual representations of human postures are viewpoint-dependent and finely tuned to a particular depth orientation. One of the purposes of the present study is to further examine this depth orientation tuning of posture representations.

Our underlying working hypothesis is that priming results from the persistent activation of representations that mediate perceptual organization of the posture. In order to perform the posture decision task during the priming phase, participants compute a representation of the posture and, when they re-encounter the posture during the test phase, activation of the representation is facilitated, resulting in shorter reaction times. The finding that even a relatively moderate depth rotation of the body posture between priming and test phase already results in a drastic reduction of facilitatory priming suggests that the underlying representations that mediate visual posture identification are sharply tuned to specific depth orientations.

However, there is an alternative explanation. Facilitatory priming was strongly dependent on the repetition of exactly

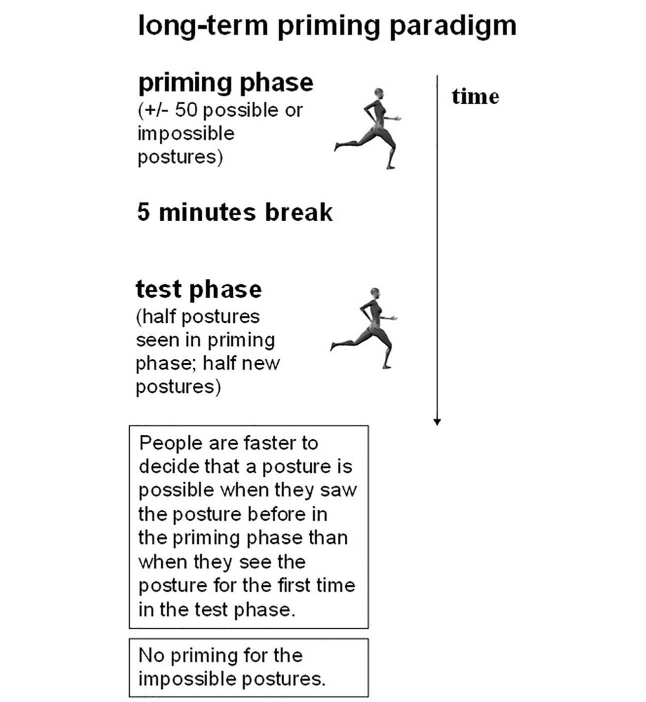

FIGURE 3 | Illustration of the basics of the long-term priming paradigm.

the same priming posture in all its details. Therefore, it is possible that priming was based on early, lower-level stimulus-specific representations that are only precursors to higher-level body representations. The observation that there was no facilitatory priming for impossible postures (see Nilsson et al., 1992; Peigneux et al., submitted), not even in the case of an identical prime-view, runs counter to this objection. Moreover, there is evidence (e.g., Cave et al., 1996; see Raffone et al., 2014, for more general related issues) that long-term priming reflects the characteristics of high-level representations, rather than lower levels of representation (although this is under debate, e.g., Srinivas, 1995) footnote 1. In Experiment 1, we tested this alternative hypothesis more directly by manipulating the visual appearance of the actor performing the posture. In Experiment 2, we examined whether privileged posture orientations (i.e., 3/4 views) could explain the divergent results between Experiment 4 of Daems and Verfaillie (1999) and the present Experiment 1. In Experiment 3, we investigated whether increasing or decreasing the variability in orientation differences between the priming figures influences subsequent priming in the test phase. The theoretical rationale relates to the potential importance of similarity of priming stimuli in the priming phase for flexible identity and orientation tuning of the postures.

EXPERIMENT 1

Long-term priming was examined with the paradigm developed by Daems and Verfaillie (1999) (see **Figure 3**). Participants performed a posture decision task in a priming block of trials, followed by a test phase. All participants saw the same test postures and the RT to decide whether a test posture was anatomically possible or not was the dependent variable. The relation between priming and test postures was manipulated in two ways. Only the possible postures were systematically involved in these manipulations; the impossible postures served as filler stimuli.

First, and most importantly for the present experiment, we manipulated the visual appearance of the actor involved in the postures. As shown in **Figure 4**, the human model either had a typical male build, had short brown hair, was wearing a dark blue trouser suit with short sleeves and trouser-legs, and was bare-footed, or had a typical female build, had medium blond hair, and was wearing a light green trouser suit with long sleeves and legs and green shoes. As shown in **Figure 5**, a posture in the test phase was personated by the same male or female actor in the priming block (same-figure prime), was personated by the other figure (different-figure prime), or was not shown during the priming phase (baseline no-prime condition). On the one hand, a body posture is determined primarily by the spatial relations between the body parts and much less by characteristics of the person performing the posture, such as her or his gender, body proportions, clothing, or hair color. If long-term priming in our paradigm is based on the reactivation of high-level posture representations that make abstraction of the identity of the human figure, priming (i.e., faster RT in the priming condition than in the baseline no-prime condition) should be observed both with same-figure primes and with different-figure primes. On the other hand, the image of the female model in a particular posture differs drastically from the image of the male model in the same posture (or vice versa). If long-term priming can be traced back to the activation of early, low-level representations, priming should be absent or at least substantially reduced when the model changes from priming to test phase.

The second purpose of Experiment 1 was an attempt to replicate the strong viewpoint dependence observed by Daems and Verfaillie (1999). The trunk of the actor in the test

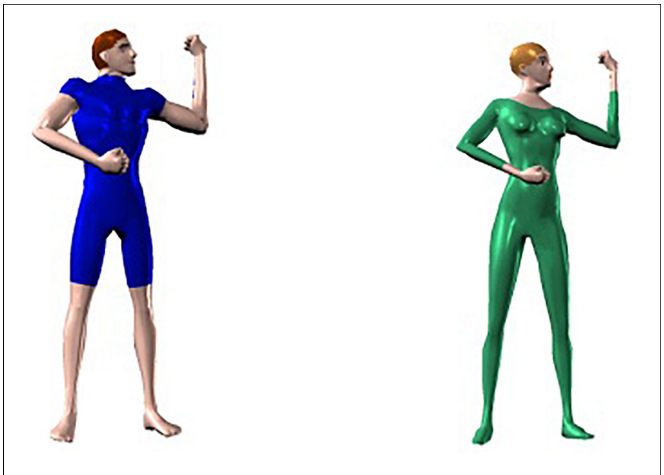

FIGURE 4 | The two actors (one male, one female) shown in Experiment 1.

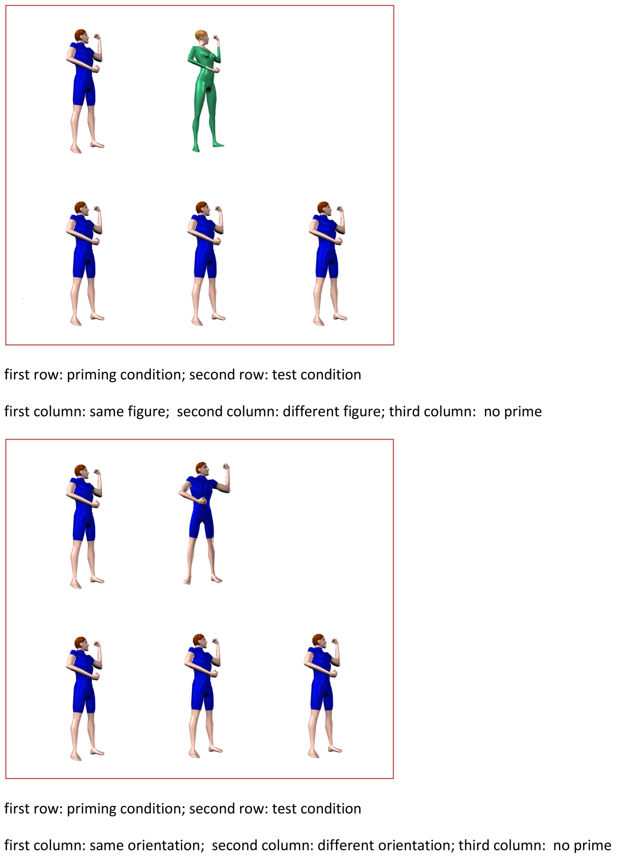

FIGURE 5 | Illustration of the priming conditions in Experiment 1. Top panel: same orientation/different figure condition; bottom panel: different orientation/same figure condition. First row in first panel: priming condition (same or different figure and same orientation, or no prime). First row in second panel: priming condition (same figure and same or different orientation, or no prime). Second row in both panels: primed condition (here figure in 45° orientation).

phase always was oriented 45° or 225° to the right. In the priming block of trials, a posture was either shown in the same depth orientation or in an orientation that differed by a depth rotation of 30° around the actor's top-bottom axis, resulting in an orientation of 15 or 195°. As shown in the top row of the bottom panel of **Figure 5**, the difference between postures in a 45 and a 15° orientation (which also holds for the difference between a 225 and a 195° orientation) was quite subtle. Nevertheless, in an experiment with a similar manipulation, Daems and Verfaillie (1999) observed that a depth rotation of only 30° between priming and test posture was sufficient to reduce the priming effect to a non-significant 6 ms benefit in comparison to a no-prime baseline. We therefore predicted reliable priming in the same-view condition and no priming in the 30°-difference condition.

For a given posture there were four different conditions: same figure/same orientation in priming and test block, different figure/same orientation, same figure/different orientation, and no prime. In principle, both the visual appearance of the human model and the precise depth viewpoint from which a posture is observed are irrelevant to perform the posture decision task. The observation that long-term priming with same figure/same orientation primes generalizes over changes in characteristics of the model but not over changes in the depth orientation of the posture would support the hypothesis that the high-level representations of human postures are viewpoint specific. Moreover, the observation that same-orientation prime-test pairs produce (relatively) equivalent facilitatory effects independently of the precise visual appearance of the actor (either same priming and test female or male figure or different figures) would indicate that posture priming primarily is determined by the spatial relations between the body parts and much less by characteristics of the person involved in the posture. This would imply that high-level posture representations to a large extent make abstraction of the identity of the human figure.

Method

Participants

Sixty-four first-year students (who received course credit) or other undergraduate and graduate students (who were paid) participated in the experiment. They were tested individually. The subjects gave informed consent in accordance with the declaration of Helsinki. All participants had normal or corrected-to-normal vision and were naive with respect to the hypothesis under investigation.

Stimuli and Apparatus

The experimental stimulus set consisted of eight sets of 24 static full-color pictures of anatomically possible human body postures. In the first set, a male bare-footed model with short brown hair and a blue trouser suit with short sleeves and trouser-legs was depicted in 24 different postures with the trunk in a 15° orientation in depth (with 0° corresponding to a frontal view). In the second set, the same model was shown in the same 24 postures, but now in a 45° depth orientation. The third and the fourth set portrayed the human figure in 24 new postures, with the trunk in a 195 and a 225° depth orientation, respectively. In the four remaining sets, the same postures were shown as in the previous four sets, but the model now was a female person with medium blond hair wearing green shoes and a green trouser suit with long sleeves and legs. Care was taken that as many body parts as possible were visible in all views.

In addition to the experimental stimulus set, 60 filler stimuli of 40 anatomically impossible postures were constructed. In these impossible poses, the above-waist part of the body was rotated 180° in depth around the model's top-bottom axis, so that the figure's above-waist part was oriented in exactly the opposite direction vis-a-vis the below-waist part of the body (**Figure 2**). The impossible poses were built from poses that were different from the possible postures in the experimental stimulus set. Half of the impossible stimuli showed the male model and the other half showed the female model. The trunk was in a 15° or a 195° depth orientation or in a 195 or 225° depth orientation.

The training stimuli consisted of the 14 training stimuli used in Experiments 3 and 4 of Daems and Verfaillie (1999).

All anatomically possible and impossible postures were created using the Poser software package (Fractal Design Corporation, 1996) and then improved with graphics software. During the experiment, stimuli were presented with a computer equipped with a VGA graphics card on a 15-inch computer screen. Stimuli were viewed binocularly at a comfortable viewing distance of approximately 65 cm. In a standing up pose, the human figure subtended approximately 10.5° of visual angle. A response box with two buttons with breaking contacts was connected to the PC.

Procedure and Design

Each trial started with the presentation of an auditory warning signal and a fixation cross in the middle of the screen. After 500 ms, the stimulus appeared and participants had to decide as rapidly as possible whether the depicted body posture was anatomically possible or not, by pressing one of two response keys. Half of the participants pressed the right button for possible poses and the left button for impossible poses, while this stimulus-response mapping was reversed for the other half of the subjects. Auditory feedback was given by means of a high-pitch tone for a correct answer and a low-pitch tone for an incorrect answer. The picture was presented until participants responded, except when the RT exceeded 2 s, in which case the trial was ended.

Participants performed this posture decision task with the 14 training stimuli, immediately followed by the priming block of 68 priming stimuli (36 experimental, anatomically possible postures and 32 filler, impossible postures) presented in an individually determined random order. After a 5 min break (during which the experimenter and the subject had an informal conversation), the testing block of 88 stimuli (48 experimental, anatomically possible postures and 40 filler, impossible postures) was administered, again in a random presentation order. During instructions, it was never mentioned that subjects were involved in a priming experiment.

There were four conditions (**Figure 5**), determined by the relation between priming and test postures: a same figure/same orientation condition, a different figure/same orientation condition, a same figure/different orientation condition, and a no-prime condition. The eight experimental stimulus sets were divided in eight groups of three stimuli that were rotated across conditions and participants, in such a way that each stimulus appeared equally often in each of the four conditions. Each participant saw 12 postures in each condition. In the same figure/same orientation condition, half of the postures were personated by the female model and half were personated by the male model, both in the priming phase and in the test phase. In the different figure/same orientation condition, half of the postures were personated by the female model in the priming phase and by the male model in the test phase, whereas the other half of the postures were personated by the male model in the priming phase and by the female model in the test phase (first two columns in the top panel of **Figure 5** for examples of same/different figures in the same orientation). In these two conditions, the postures were always shown in the same depth orientation (45 or 225°) in priming and test block. In the same figure/different orientation condition, half of the postures were personated by the female model and half by the male model, and for a given posture the model was constant over the priming and the test block (first two columns in the bottom panel of **Figure 5** for examples of same figures in different orientations). The depth orientation of the priming posture differed by 30° from the test posture. Finally, in the no-prime condition, half of the postures were personated by the female model and half by the male model and were shown for the first time in the test block (third column in both panels of **Figure 5**).

All participants saw the same anatomically impossible filler stimuli. During the priming block and the test block, 32 and 40 impossible postures were shown, respectively, half of them personated by the male model and half by the female model. In both phases, half of the male and half of the female postures were oriented (more or less) toward the viewer (15 or 45° in the priming phase and 45° in the test phase) and half were oriented (more or less) away from the viewer (195 or 225° in the priming phase and 225° in the test phase). Twelve impossible postures were shown by the same figure and in the same depth orientation in priming and test phase, 10 impossible postures were performed by the same figure but shown from a different viewpoint in the test phase, and 10 impossible postures were shown from the same viewpoint, but were performed by the other person in the test phase. The remaining eight impossible filler stimuli were only administered during the test phase.

Results

The dependent variable was the RT to the (anatomically possible) test postures. Trials in which the stimulus was not identified correctly either in the priming or in the test block and trials in which the RT fell below a cut-off value of 200 ms or above a cut-off value of 2000 ms were discarded from the RT data set (approximately 1% of the data set). The remaining RTs were entered in a subject repeated-measures analysis of variance (ANOVA) with priming condition (identical prime, different figure but same orientation, same figure but different orientation, and no prime) as a within-subject variable and participant group as a between-subjects variable, and in a stimulus ANOVA with priming condition as within-stimulus variable and stimulus group as between-stimuli variable. (Especially in psycholinguistic research, but also in perception research, it is informative to perform both subject and stimulus analyses and present them together, Kirk, 1968; Pittenger, 2003, as we did in previous analyses of experiments with the same paradigm; Daems and Verfaillie, 1999; Verfaillie and Daems, 2002). The mean RTs are shown in **Table 1**. The MS errors in the ANOVAs give an indication of the variability.

Both the subject and the stimulus analysis revealed a statistically significant main effect of priming condition (4 levels: same figure, same orientation; different figure, same orientation; same figure, different orientation, no prime), $F_1(3,168) = 6.04$, $MSe = 1989$, $p < 0.01$, and $F_2(3,120) = 6.24$, $MSe = 1890$, $p < 0.01$. Dunn's multiple comparison test showed that RTs in the no-prime baseline condition were significantly longer than in the identical same-figure/same-orientation condition, $tD_1 = 3.64$, $MSe = 2339$, $p < 0.01$, and $tD_2 = 3.97$, $MSe = 1812$,

$p < 0.01$, in the different-figure/same-orientation condition, $tD_1 = 2.74$, $MSe = 2229$, $p < 0.05$, and $tD_2 = 2.83$, $MSe = 2441$, $p < 0.05$, and in the same-figure/different-orientation condition, $tD_1 = 3.52$, $MSe = 1686$, $p < 0.01$, and $tD_2 = 3.29$, $MSe = 1949$, $p < 0.01$. The differences between RTs in the identical condition and the different-figure condition and between RTs in the identical condition and the different-orientation condition were not significant.

Note that the long-term priming effects in the test phase were not caused by (accidental) differences in exposure times to the initial, priming postures. Indeed, a subject and stimulus analysis on the RTs in the priming phase showed that long-term priming condition had no effect, $F_1(2{,}112) = 0.49$, $MSe = 3222$, $p > 0.60$, and $F_2(2{,}80) = 1.22$, $MSe = 4273$, $p < 0.30$. Mean RTs to postures that later appeared in the identical condition, the different figure condition, and the different orientation condition were 873, 882, and 875 ms, respectively.

Discussion

First, in comparison to the no-prime baseline, participants were faster to decide that a posture was anatomically possible when they had seen that posture several minutes earlier during the priming phase. Most importantly, this priming effect was not significantly larger when the human model in the priming posture was identical to the model in the test phase than when priming and test postures were personated by distinctly different human models. Apparently, facilitatory long-term priming in the posture decision task is not contingent upon the repetition of exactly the same stimulus person. This supports the hypothesis that long-term priming is based on the re-activation of high-level representations of human body postures (rather than being based on an early, low-level representation of the stimulus) that make abstraction of the precise visual appearance of the human figure.

Second, contrary to our expectations, priming also generalized over an orientation difference of 30° between priming and test posture. On the one hand, given the fact that the difference between postures in a 45 and a 15° orientation and between a 225 and 195° orientation was quite subtle (see **Figure 5** for examples), this is not surprising. On the other hand, in a similar experiment, Daems and Verfaillie (1999) did not observe significant facilitatory priming with a depth orientation difference of 30° between priming and test posture. For comparison, in Experiment 4 of Daems and Verfaillie (1999), the priming effect (difference with the no-prime baseline) amounted to 27 ms in the identical condition (31 ms in the present study), but only to 6 ms in the condition with a 30° orientation difference (25 ms in the present study). The experiment of Daems and Verfaillie (1999) suggests that posture representations are very sharply tuned to a particular orientation in depth, while the present study suggests that the orientation tuning of action representations is broader (or at least dependent on stimulus or task conditions). One of the purposes of Experiments 2 and 3 was to test possible accounts for these divergent findings.

TABLE 1 | Mean identification time (in ms) of anatomically possible human postures in the test phase of Experiment 1 as a function of long-term priming condition.

Long-term priming condition	RT to possible body postures
Same figure/same orientation	615
Different figure/same orientation	624
Same figure/30° different orientation	621
No priming	646

EXPERIMENT 2

A possible explanation for the contradictory findings in our previous experiments hinges on the hypothesis that some views of body postures might have a privileged status over other views and that posture recognition proceeds through the activation of these privileged or prototypical orientations. Evidence mainly comes from studies of object recognition.

First, there is ample evidence that some views of three-dimensional, familiar objects are rated as more canonical or prototypical than other views and that objects depicted in canonical orientations are identified more easily (e.g., faster) than when shown from less canonical angles (e.g., Palmer et al., 1981; Verfaillie and Boutsen, 1995; Lawson and Humphreys, 1996, 1998; Boutsen et al., 1998; Blanz et al., 1999; Ghose and Liu, 2013; Alshehri et al., 2018; but see Cutzu and Edelman, 1994, and Niemann et al., 1996, who did not find evidence for universally valid canonical views for novel objects). Stable views (e.g., a 3/4 view) typically are views in which small changes in depth orientation do not lead to prominent changes in the projected image of the object and that are most informative about the identity of an object (e.g., because the most diagnostic object parts are clearly visible; see Verfaillie and Boutsen, 1995, for a more detailed discussion). It is possible that body postures (and not only objects in general) in a 3/4 depth orientation also have a privileged status.

Second, it has been suggested that identification of objects, even objects viewed from unconventional viewing angles, is achieved by activating (a number of) neighboring prototypical views (for an overview on this discussion, see Bülthoff et al., 1995; Ghose and Liu, 2013). For instance, using a long-term priming paradigm, Srinivas (1993) reported that having seen an object shown in an unusual orientation during the priming phase produced almost as much facilitation to identify that object shown in a usual orientation in the test phase as having seen the same object in the same (usual) orientation during the priming phase. Having seen an object in a usual orientation during the priming phase, in contrast, did not facilitate later recognition of the object in an unusual orientation in the test phase. Apparently, processing an object seen from an unusual viewpoint in the priming phase involved the activation of a representation of the object in a neighboring, more prototypical view, resulting in facilitatory priming during the test phase (see Perrett et al., 1989; Perrett et al., 1991, for related neurophysiological findings).

The test postures in Experiment 4 of Daems and Verfaillie (1999) were always in a less prototypical orientation (75 or 255°), whereas the test postures in Experiment 1 of the present study were in a more prototypical orientation (45 or 225°).

This might explain why, when priming and test posture differed by a 30° depth rotation, facilitatory priming was observed in the latter experiment but not in the former experiment. If the discrimination between possible and impossible body postures in less prototypical orientations indeed involves the activation of neighboring prototypical orientations, the less prototypical 15 and 195° priming postures (the priming postures in the 30° different conditions in Experiment 1 of the current study) would result in priming during the test phase, whereas the prototypical 45 and 225° priming postures (the priming postures in the 30° different conditions in Daems and Verfaillie's Experiment 4) would not.

In Experiment 2, the test postures were shown either in a prototypical 45 or 225° orientation (further referred to as the three-quarter views) or in a less prototypical 75 or 255° orientation (further referred to as the sagittal views, even though strictly spoken the views only approximate the 90 and 270° sagittal views; note that one of the reasons for choosing these views close to the sagittal views instead of the exact sagittal views is that body parts that were occluded in the sagittal views mostly became visible in the close-to-sagittal views). These test postures were preceded by a posture in the same view, the same posture in a view that differed by a rotation of 30° (15 or 195° and 45 or 225°), or were not shown during the priming phase. Of crucial importance is the condition in which priming and test postures differed by 30°. As spelled out in previous paragraphs, facilitatory priming (i.e., shorter RTs in comparison to the no-prime condition and RTs at the same level as in the identical prime condition) was predicted in this condition for test postures in prototypical three-quarter orientations but not for test postures in less prototypical sagittal orientations. The underlying rationale is that the 30° different prime preceding the three-quarter test posture is a less prototypical view and processing this view also activates the three-quarter view, whereas the 30° different prime preceding the sagittal test posture is a prototypical view and processing this view does not lead to activation of less prototypical views. Support for this hypothesis would imply that, first, postures in some orientations have a more privileged status than postures in other orientations and, second, posture decision proceeds through the activation of neighboring privileged views.

Method

Participants

A total of 84 first-year students psychology at the Leuven University with normal or corrected-to-normal vision participated for course credit. Participants were tested individually.

Stimuli

The experimental stimulus set consisted of six sets of 24 color pictures of a male figure. The first three sets depicted the figure in 24 different anatomically possible body postures with the trunk in a 15, 45, or 75° depth orientation, respectively. In the other three sets, the same figure was shown in 24 other postures in a 195, 225, or 275° depth orientation, respectively. **Figure 6** depicts an example of two postures, each in three different depth orientations. In addition to the experimental stimuli, 48 filler stimuli of 36 different anatomically impossible postures were created in the same way as in Experiment 1. The lower body part was in a 15, 45, 75, 195, 225, or 255° orientation in depth.

FIGURE 6 | Example of the stimuli used in Experiment 2. The trunk is in a 15°, 45°, or 75° degrees depth orientation (top row) or a 195°, 225°, or 275° depth orientation (bottom row).

Procedure and Design

Participants performed the same posture decision task as in Experiment 1. All participants saw exactly the same test postures, but different subjects saw different priming postures.

The six sets of experimental stimuli were divided in six groups of four stimuli that were rotated across conditions and across participants. Each participant was presented with eight different postures in each of six conditions. In three conditions, three-quarter views (45 and 225°) were shown during the test phase and in three other conditions, views close to the sagittal orientation (75 and 255°) were shown during the test phase. One third of the three-quarter and quasi sagittal test postures were preceded by the same posture in the same orientation during the priming phase, one third of the test postures were preceded by the same posture rotated by 30° in depth vis-a-vis the test stimulus (i.e., in a 15 and 195° orientation for the three-quarter views and a 45 and 225° orientation for the sagittal views), and one third of the test postures were not shown during the priming phase. All participants saw the same anatomically impossible postures. In half of the impossible postures presented during the test phase, the lower body part half was in a 45 or 255° depth orientation, in the other half, the lower body part was in a 75 or 255° orientation. One third of the impossible test postures were seen in the same depth orientation during the priming phase, one third in a 30°-different orientation, and one third was seen for the first time during the test block of trials. These impossible postures only served as filler stimuli and RTs to impossible postures were not analyzed.

Participants were tested individually. They started the experiment with a block of 14 training stimuli (the same as in Experiment 1), which was followed by a priming block of 56 stimuli presented in a random order (32 possible experimental stimuli and 24 impossible filler stimuli), a 5 min break, and a test block of 84 stimuli in a random order (48 experimental possible stimuli and 36 impossible filler stimuli).

TABLE 2 | Mean identification time (in ms) of anatomically possible human postures in the test phase of Experiment 2 as a function of long-term priming condition and test orientation.

	Test orientation	
Long-term priming condition	**Three-quarter view**	**Sagittal view**
Same orientation	616	616
30° different orientation	638	625
No priming	658	650

Results

The RT to decide that a test posture was anatomically possible was the dependent variable. Using the same criteria as in Experiment 1, about 1% of the trials were excluded from analysis. Means of the remaining RTs, as a function of priming condition and test orientation are shown in **Table 2** (the MS error values of the ANOVA provide information about the variability).

The data were entered in a participant ANOVA with test orientation (three-quarter view or almost sagittal view) and priming condition (same orientation prime, 30° orientation-different prime, or no prime) as within-subject variables and participant group as between-subjects variable, and in a stimulus ANOVA with test orientation and priming condition as within-stimulus variables and stimulus group as between-stimuli variable. The participant and the stimulus analysis yielded a significant main effect of priming condition, $F_1(2,156) = 18.68$, $MSe = 3329$, $p < 0.001$, and $F_2(2,84) = 20.13$, $MSe = 1874$, $p < 0.001$. Dunn's multiple comparison tests showed that, both in the participant and in the stimulus analysis, RTs in the no-prime condition were significantly longer than in the same-orientation condition, $tD_1 = 6.40$, $MSe = 6008$, $p < 0.01$, and $tD_2 = 5.78$, $MSe = 4501$, $p < 0.01$, and in the 30°-different condition, $tD_1 = 3.64$, $MSe = 6552$, $p < 0.01$, and $tD_2 = 3.24$, $MSe = 4298$, $p < 0.01$. This indicates that there was facilitatory priming, both in the same-orientation condition and in the 30°-different orientation condition. In the stimulus analysis, RTs in the same-orientation condition were shorter than in the 30°-different orientation condition, $tD_2 = 3.54$, $MSe = 2447$, $p < 0.01$, suggesting that facilitatory priming was more pronounced in the same-orientation condition than in the 30°-different condition. However, this difference was not significant in the participant analysis.

The main effect of test orientation was not significant, $F_1(1,78) = 2.25$, $MSe = 2642$, $p > 0.10$, and $F_2(1,42) = 1.39$, $MSe = 2586$, $p > 0.20$, nor was the interaction between test orientation and priming condition, $F_1(2,156) = 0.63$, $MSe = 2884$, $p > 0.50$, and $F_2(2,84) = 1.01$, $MSe = 2083$, $p > 0.30$. This is not in line with the predictions. In fact, although not significantly different, RTs to the three-quarter views, which were supposed to have a more privileged status, were slightly longer than RTs to the test postures close to the sagittal view.

Note that again the priming effects in the test phase were not caused by differences in initial identification time during the priming phase, as shown by the absence of main effects of test orientation and priming condition and the absence of an interaction effect in a participant and stimulus analysis on the reaction times in the priming phase. With the three-quarter view test orientation, mean identification time of the priming posture was 862 ms for the same-orientation condition and 852 ms for the 30° different-orientation condition. With the almost frontal view test orientation, mean identification time of the priming posture was 851 ms for the same-orientation condition and 854 ms for the 30° different-orientation condition.

Discussion

For both test orientations in Experiment 2, we observed long-term priming that was less orientation specific (i.e., priming in the 30° difference condition larger than in the no-prime baseline but smaller than in the identical orientation condition) than in Experiment 4 of Daems and Verfaillie (1999) (where no priming with a 30° orientation difference was found), but more orientation specific than in Experiment 1 of the present study (where priming with a 30° difference, but not different from the identical-orientation condition, was found). Moreover, although not significant, the data in **Table 2** suggest that generalization across 30° different orientations was more pronounced with the test postures in an almost sagittal orientation than with the test orientations in a three-quarter view, contrary to what we predicted. It is therefore improbable that the specific test orientations were responsible for the differential orientation tuning effects observed in previous long-term priming experiments.

From a theoretical point of view, these findings have implications for a better understanding of visual representations of human body postures. More specifically, we did not find evidence for the assumption that postures in a three quarter view are processed as prototypical postures nor that body postures in nearby orientations are recognized via the activation of prototypical half-way orientations. Note, however, that the hypothesis that prototypical orientations play a role in the identification of postures in less prototypical orientations can only be rejected with caution. The assumption underlying this hypothesis was that the presence of non-prototypical orientations in the priming phase could result in the activation of similar prototypical views, so that these prototypical orientations are processed more easily later during the test phase. However, this facilitatory effect in principle could also occur when prototypical orientations are shown during the priming phase and non-prototypical orientations during the test phase. In theory it is indeed possible that the presentation of prototypical orientations in the priming phase results in faster activation of these representations in the test phase, facilitating the activation of test postures in non-prototypical orientations that are recognized through the activation of these representations. What does seem to be clear on the basis of Experiment 2, however, is that prototypical orientations are not responsible for the divergent results in Experiment 4 of Daems and Verfaillie (1999) and the present Experiment 1.

EXPERIMENT 3

The design of Experiment 4 in Daems and Verfaillie (1999) and that of Experiment 1 of the present study differ in several respects. In Experiment 3, we tested the effect of one specific difference: the smallest orientation difference between the orientations in the priming phase (in the conditions in which priming and test orientations differed). Indeed, in Experiment 4 of Daems and Verfaillie (1999) the smallest difference between the body postures presented during the priming phase was 15° whereas the smallest difference amounted to 30° in Experiment 1 of the present study. It is possible that smaller differences between different orientations in a stimulus set in the priming phase result in more specific long-term priming effects than larger differences.

Under the assumption that different body postures in orientations that are closer to each other are more similar than postures in orientations that are farther apart, this fits with findings in the object recognition literature. It has indeed been shown that object identification becomes more orientation specific as objects in the stimulus set become more similar (e.g., Edelman, 1995, 1999; Murray, 1998; Newell, 1998; Humphreys and Forde, 2001; Rosselli et al., 2015). Human postures constitute a relatively homogeneous stimulus set, but the visual similarity becomes even larger when the postures are presented in the same or minimally different orientations. The trunk is the central part of the human body and the orientation of the limbs is specified vis-à-vis the trunk. Because the difference between the presented postures mostly is determined by the orientation of the limbs, more than by the orientation of the trunk, the visual projections of the trunk in different stimuli in the same orientations are very similar. Although the orientation of the trunk in some of the stimuli varies in the midsagittal plane (e.g., in a jumping down posture), the orientation in the midtransversal plane mostly remains constant (**Figure 7**).

The orientation differences in Experiment 4 of Daems and Verfaillie (1999) and Experiments 1 and 2 of the present study were realized by rotating the trunk in the midtransversal plane. Small rotations result in less drastic changes in the projection of the trunk than large rotations and therefore lead to less pronounced differences in the projection of the trunk and consequently cause smaller image changes between different postures (**Figure 8**).

FIGURE 8 | Illustration of the fact that small rotations result in less drastic changes in the projection of the trunk than large rotations (first row: two postures in more or less frontal view (75 and 60°) that differ by 15° in depth; second row: two postures in more or less frontal view (75 and 45°) that differ by 30° in depth; third row: two postures in more or less back view (255 and 240°) that differ by 15° in depth; fourth row: two postures in more or less back view (255 and 225°) that differ by 30° in depth).

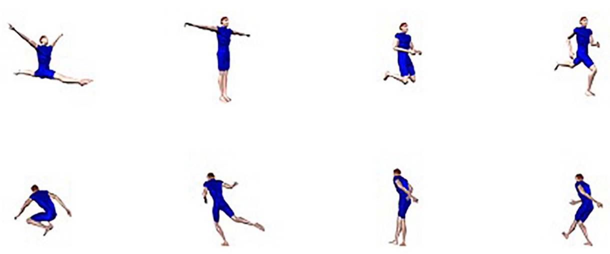

FIGURE 7 | Examples of postures with the trunk in a 45° (first row) or 225° (second row) depth orientation. Note that the orientation of the trunk more or less remains the same in each row.

It has been suggested (e.g., Perrett et al., 1991; Logothetis et al., 1995) that discrimination between visually similar objects leads to finer orientation tuning in neurons in infero-temporal cortex (IT). In order to identify body postures in a stimulus set with small orientation differences, the visual system might also rely on more finely tuned representations that result in stronger orientation-dependent effects. Stimulus sets with larger orientation differences then would lead to the activation of more broadly tuned representations causing more generalization.

The purpose of Experiment 3 was to examine to what degree the extent of the orientation differences between different body postures in the priming phase could explain the divergent results of Experiment 4 of Daems and Verfaillie (1999) and Experiment 1 of the present study. Two groups of participants were tested in the same possible/impossible decision task as used in the previous experiments. In one group participants were presented with body postures in a 15, 45, and 75° or in a 195, 225, and 255° orientation during the priming phase (relatively large orientation differences). In the second group postures were shown in a 45, 60, and 75° orientation or in a 225, 240, and 255° orientation in the priming phase (relatively small orientation differences). Both groups only saw postures in 75 and 255° orientations during the test phase. This design allowed us to investigate the degree to which long-term priming generalizes across a 30° orientation difference depending on the range of orientations used in the experiment.

Method

Participants

Two groups of 60 subjects participated to the experiment. All participants had normal or corrected-to-normal vision and were tested individually. Subjects either were first or second year students who participated for course credit or were phd students.

FIGURE 9 | Examples of stimuli used in Experiment 3 (first row: possible posture in 15, 45, and 75° depth orientation; second row: possible posture in 195, 225, and 255° orientation; third row: impossible posture with lower body in 15, 45, and 75° orientation; fourth row: impossible posture with lower body in 195, 225, and 255°).

Stimuli

A total of 16 stimulus sets from Experiment 4 in Daems and Verfaillie (1999) were used. The first group of participants were presented with 12 sets. Three sets consisted of 24 anatomically possible postures that were oriented respectively 15,45, and 75° to the right (see **Figure 9** for examples) and three sets consisted of 24 anatomically possible postures oriented 195, 225, and 255° to the right. The remaining six stimulus sets contained impossible postures with the lower body oriented 15, 45, and 75° oriented to the right in the first three sets and 195, 225, and 255° to the right in the other three sets. For the second group of participants, the 15 and 195° sets were replaced by the 60 and 240° sets of Experiment 4 in Daems and Verfaillie (1999). The other sets were the same as in the first group of participants. In addition to the experimental stimuli, there were 14 training stimuli.

Procedure

Participants were randomly assigned to the two groups. The first group participated in the condition with large orientation differences between the stimuli in the priming phase and the second group participated in the condition with small orientation differences in the priming phase. The stimuli in the test phase always were oriented 75 or 255° to the right. In the condition with large orientation differences stimuli in the priming phase either had the same orientation as in the test phase (75 or 255°), a 30° different orientation (45 or 225°), a 60° different orientation (15 or 195°), or there was no priming. In the condition with small orientation differences stimuli in the priming phase had the same orientation as in the test phase (75 or 255°), a 15 difference (60 or 240°), a 30° difference orientation (45 or 225°), or there was no priming. The smallest orientation difference between different stimuli in the priming phase therefore was 30° in the condition with large orientation differences and 15° in the condition with small orientation differences. In both conditions 12 anatomically possible and 12 impossible stimulus sets were divided over 4 groups of 6 stimuli that were rotated across long-term priming conditions and participants. Each participant was presented with 12 anatomically possible and 12 impossible postures in each long-term priming condition. Half of these 12 anatomically possible and 12 impossible postures were shown in a (more or less) frontal view (15, 45, and 75 or 45, 60, and 75°) and the other postures in a (more or less) back view (195, 225, and 255 or 225, 240, and 255°). The experiment always started with the training stimuli and 72 priming stimuli presented in a random order. After a short break, the 96 test stimuli were administered, also in a random order.

Results

Reaction times below 200 ms or above 1400 ms (about 1% of the data), reaction times to stimuli that were not identified correctly in the priming phase or the test phase, and reaction times to three impossible postures that were identified correctly by less than half of the participants in both phases were removed from the data set. Mean RTs to anatomically possible and impossible postures can be found in **Table 3**. The MS errors in the subsequent ANOVAs give an impression of the variability in the data.

In a first series of analyses, RTs to stimuli in the 60° difference condition in the first group of participants (who were presented with relatively large orientation differences, but not the 15° difference) and RTs to stimuli in the 15° difference condition in the second group (who were presented with relatively small orientation differences, but not the 60° difference) were not taken into account. All other RTs from the test phase were entered in a participant and stimulus repeated-measures ANOVA with range of orientations (relatively large or small orientation differences in the priming phase) as between subjects variable or within stimuli variable, long-term priming condition (same orientation condition, 30° difference condition, or no priming) as within subjects variable or within stimuli variable, stimulus type (anatomically possible or impossible postures) as within subjects variable or between stimuli variable, and subject group or stimulus group as between subjects variable or between stimuli variable.

In the subject analysis as well as in the stimulus analysis, there was a main effect of stimulus type, $F_1(1,112) = 151.84$, $MSE = 7070$, $p < 0.001$; $F_2(1,85) = 44.80$, $MSE = 17608$, $p < 0.001$, a main effect of long-term priming condition, $F_1(2,224) = 11.36$, $MSE = 1945$, $p < 0.001$; $F_2(2,170) = 10.37$, $MSE = 1646$, $p < 0.001$, and no main effect of range of orientations condition, $F_1(1,112) = 0.09$, $MSE = 44447$, $p > 0.70$; $F_2(1,85) = 0.46$, $MSE = 1750$, $p > 0.50$. The interaction between stimulus type and range of orientations was marginally significant in the subject analysis, $F_1(1,112) = 3.62$, $MSE = 7070$, $p < 0.06$, and significant in the stimulus analysis, $F_2(1,85) = 9.75$, $MSE = 1750$, $p < 0.01$. Participants identified anatomically possible postures faster and impossible postures slower in the condition with small orientation changes than in the condition with large orientation changes. There was no significant interaction between stimulus type and long-term priming condition, $F_1(2,224) = 1.17$, $MSE = 1935$, $p > 0.30$; $F_2(2,170) = 1.53$, $MSE = 1645$, $p > 0.20$, between long-term priming condition and range of orientations, $F_1(2,224) = 0.03$, $MSE = 1945$, $p > 0.90$; $F_2(2,170) = 0.00$, $MSE = 1668$, $p > 0.90$, and between stimulus type, range of orientations, and long-term priming condition, $F_1(2,224) = 1.96$, $MSE = 1935$, $p > 0.10$; $F_2(2,170) = 1.63$, $MSE = 1668$, $p > 0.10$.

Even though stimulus type only interacted with range of orientations condition and not with long-term priming, separate analyses were performed for the anatomically possible and impossible postures. Differences between the same orientation condition, the 30° difference condition, and the condition without priming were evaluated by means of Dunn's multiple comparison procedure. In the possible posture condition with large orientation differences, the difference between RTs in the same orientation condition and the condition without priming and in the condition with 30° different orientations and the condition without priming were significant in the subject and the stimulus analysis, $tD_1 = 2.53$, $MSE = 2187$, $p < 0.05$; $tD_2 = 2.83$, $MSE = 1783$, $p < 0.05$, and $tD_1 = 2.66$, $MSE = 1777$, $p < 0.05$; $tD_2 = 3.47$, $MSE = 817$, $p < 0.01$. In the condition with small orientation differences, we observed a quasi opposite effect. RTs in the same orientation condition differed significantly from RTs in the no-prime condition both in the subject and the stimulus analysis, $tD_1 = 3.73$, $MSE = 986$, $p < 0.01$; $tD_2 = 2.63$, $MSE = 1543$, $p < 0.05$, but the RT difference between the 30° different condition and the no-prime condition was not significant in both analyses. The difference between the same orientation condition and the 30° different condition was significant in the subject analysis, $tD_1 = 2.89$, $MSE = 870$, $p < 0.05$, but not in the stimulus analysis.

The data indicate that long-term priming effects are modulated by the magnitude of the orientation differences between the stimuli in the priming phase. This is supported when also reaction times to stimuli in the 60° difference condition in the group of participants who were presented with large orientation differences and the reaction times to stimuli in the 15° difference condition in the group of participants who were presented with small orientation differences were taken into account (**Table 3**). The condition with 30° orientation differences resulted in significant long-term priming when the smallest orientation difference in the priming phase was 30°, but not when the smallest difference was 15°. The 60° different condition in the condition with large orientation differences did not result in long-term priming and the 15° different condition in the condition with small orientation differences resulted in a strong long-term priming effect, $tD_1 = 4.03$, $MSE = 1455$, $p < 0.01$; $tD_2 = 3.27$, $MSE = 1472$, $p < 0.01$. In the condition with large orientation differences as well as in the condition with small orientation differences a linear trend was observed ($F_1(1,56) = 10.79$, $MSE = 1929$, $p < 0.01$; for the condition with large orientation difference, and $F_2(1,44) = 11.59$, $MSE = 1728$, $p < 0.01$, for the condition with small orientation differences). Other trends were not significant.

In the condition with impossible postures (**Table 3**), no reliable differences or significant trends were found in the

TABLE 3 | Mean identification time (in ms) of possible and impossible human postures in the test phase of Experiment 3 as a function of context condition (large vs. small orientation differences) and long-term priming condition (same orientation, 15, 30, or 60° difference, or no priming).

	Possible postures		Impossible postures	
Priming condition	Large orientation difference	Small orientation difference	Large orientation difference	Small orientation difference
Same ori	640	628	709	728
15° difference	–	622	–	714
30° difference	642	644	710	718
60° difference	660	–	720	–
No priming	662	650	721	743

condition with large orientation differences. In the condition with small orientation differences there was a difference between the no-priming condition and the 15° difference condition in the subject and the stimulus analysis, $tD_1 = 4.55$, $MSE = 1272$, $p < 0.01$; $tD_2 = 2.68$, $MSE = 1948$, $p < 0.05$, and between the no-prime condition and the 30° difference condition in the stimulus analysis, $tD_2 = 2.84$, $MSE = 1712$, $p < 0.05$.

A subject and stimulus analysis on the RTs in the priming phase (**Table 4**) indicated that the long-term priming effects in the test phase probably were not caused by differences in initial identification times. The RTs below 200 ms or above 1700 ms (about 1% of the data), the RTs of incorrect answers, and the RTs to 3 impossible postures that were recognized by less than half of the participants were discarded from the analysis. In both the subject and the stimulus analysis, there was a main effect of stimulus type, $F_1(1,112) = 25.09$, $MSE = 11720$, $p < 0.001$; $F_2(1,85) = 12.82$, $MSE = 20676$, $p < 0.001$, and of long-term priming condition, $F_1(1,112) = 6.30$, $MSE = 5334$, $p < 0.05$; $F_2(1,85) = 6.23$, $MSE = 5192$, $p < 0.05$, and no main effect of range of orientations condition. Stimulus type significantly interacted with range of orientations condition, $F_1(1,112) = 7.09$, $MSE = 11720$, $p < 0.01$; $F_2(1,85) = 23.71$, $MSE = 3266$ $p < 0.001$. There were no other significant two-way or three-way interactions.

In an analysis of the mean identification times to anatomically possible postures in the priming phase as a function of long-term priming condition and range of orientations condition there was only one reliable difference in the subject analysis. Participants were faster to respond in the same-orientation condition (75 and 255° orientations) than in the 30° difference orientation condition (25° and 225° orientations) in the condition with small orientation differences, $tD_1 = 2.68$, $MSE = 3461$, $p < 0.05$. This implies that on average 45 and 225° orientations in this condition were viewed for a longer period of time than the 75 and 255° orientations. Yet, these conditions resulted in less pronounced long-term priming effects than in the condition with large orientation differences. It is therefore improbable that this difference between the same-orientation and the 30° difference condition in the priming phase was responsible for the range-of-orientations-dependent long-term priming effects observed in the test phase.

The analysis of the mean identification times for the impossible postures in the priming phase as a function of range of orientations condition and long-term priming condition indicated that in the condition with large orientation differences participants reacted more slowly in the 60° difference condition (15 and 195° orientation) than in the two other conditions ($tD_1 = 4.53$, $MSE = 8096$, $p < 0.01$; $tD_2 = 5.18$, $MSE = 6276$, $p < 0.01$ for the comparison with the same-orientation condition and $tD_1 = 4.10$, $MSE = 8409$, $p < 0.01$; $tD_2 = 5.49$, $MSE = 5402$, $p < 0.01$ for the comparison with the 30° difference condition). In the condition with small orientation differences impossible postures were identified faster in the 15° orientation difference condition (60 and 240° orientations) than in the 30° orientation difference condition (45° and 225° orientations), $tD_1 = 2.57$, $MSE = 5390$, $p < 0.05$; $tD_2 = 2.76$, $MSE = 5364$, $p < 0.05$. However, in the condition with large orientation differences as well as in the condition with small orientation differences there were no indications that RTs in the test phase were influenced by these initial identification differences.

We performed additional analyses on RTs for anatomically possible poses and for impossible poses in the priming phase with long-term priming condition, range of orientations condition, and global orientation (frontal or back view) as independent variables, but there were no significant interaction effects.

Discussion

Experiment 3 showed that long-term priming is influenced by the extent of the orientation differences between the stimuli in the priming phase. When the orientation difference between stimuli was at least 30°, there were significant long-term priming effects in the 30° different-orientation condition. When a number of stimuli only differed by 15°, no long-term priming was observed in the same 30° different-orientation condition. These results can be interpreted in at least two ways. First, it is possible that the presence of a large 60° orientation difference resulted in broader tuning of the representational system, leading to more generalization over orientations. However, this explanation is improbable. The presence of a 60° different orientation condition in Experiment 4 of Daems and Verfaillie (1999) did not result in generalization over a 30° orientation difference. Moreover, participants in the condition with small orientation differences were also confronted with large orientation differences between different postures by the use of frontal and back views.

Apparently, not the presence of a 60° difference in the condition with large orientation differences, but the presence of a 15° difference in the condition with small orientation differences was crucial. Small orientation differences in the priming phase of a long-term priming experiment seem to result in finer orientation tuning of the representations that are used to identify body postures. This is remarkable. As can be observed in **Figure 8**, a 15° orientation difference is very subtle. Moreover, participants saw different postures in different orientations. Also, it was not necessary to attend the global orientation of the postures to be able to perform the possible/impossible decision task. Nevertheless, the visual system takes into account the size of the orientation differences between postures. In the case of relatively large differences more broadly tuned representations come into play leading to less specific long-term priming, while in the case of small differences finer tuning occurs leading to relatively stronger orientation-dependent priming.

It has been shown before that the extent of generalization for a stimulus in a particular orientation is variable and that it depends on the circumstances under which identification takes place. For example, when two orientations are connected by apparent motion, representations are tuned in such a way that short-term priming between the two orientations is facilitated, whereas priming outside the movement path is inhibited (Kourtzi and Shiffrar, 1997, 1999; see Cutting and Kozlowski, 1977; Loula et al., 2005; Prasad and Shiffrar, 2009, for examples of related research on the identification of people on the basis of their movement). Motion therefore influences the size and the nature of the generalization field around visual stimuli. The results of Experiment 3 indicate that the same holds for

TABLE 4 | Mean identification time (in ms) of possible and impossible human postures in the priming phase of Experiment 3 as a function of context condition (large vs. small orientation differences) and long-term priming condition (same orientation, 15°, 30°, or 60° difference).

Priming condition	Possible postures		Impossible postures	
	Large orientation difference	Small orientation difference	Large orientation difference	Small orientation difference
Same orientation	919	889	944	968
15° difference	–	912	–	956
30° difference	929	918	950	991
60° difference	939	–	1019	–

stimulus context (the range of orientations). Generalization fields shrink as the orientation difference between the to be identified stimuli decreases.

This observation fits with findings on object perception. Indeed, it has been reported repeatedly that object recognition becomes more orientation specific as the similarity of the objects in the stimulus set is more pronounced (Edelman, 1995; Murray, 1998; Newell, 1998, also see Perrett et al., 1991; Logothetis et al., 1995). Edelman (1999) explains this effect in a model in which similarity is represented in terms of distances. Similar orientations of an object are close to each other in an orientation space and the orientation spaces of similar objects are close to each other in a shape space. Therefore, the representation of an object in a particular orientation is codetermined by the representation of similar objects in the same orientation (also see Gauthier and Tarr, 1997; Tarr and Gauthier, 1998), making discrimination between similar objects in similar orientations more difficult.

In **Figure 10** a similar model for the perception of body postures is depicted. In this model the similarity between different orientations of two different postures is shown. This representation shows that (the projection of) different postures in the same or minimally different orientations are visually more similar than different postures (or even the same posture) in strongly different orientations.

The model in **Figure 10** should not be conceived of as a static memory model for specific body postures. A considerable number of participants in Experiment 3 probably never encountered the specific postures as shown in **Figure 10**. Apart from a few exceptions (e.g., walking, crawling), for most body postures participants cannot access a specific memory model. Instead, the visual system utilizes a general dynamic body scheme that can be set into the correct orientation and posture. In the case of close orientations of similar postures, this process probably proceeds in a more similar manner, as a result of which the dynamic representations involved are overlapping to a considerable degree. In this sense, the distances in the model in **Figure 10** stand for the relative similarity between pairs of body postures in different orientations on the one hand, and the relative overlap of the dynamic representations on the other hand.

The context (i.e., the range of orientations used) dependent long-term priming effects in Experiment 3 suggest that the underlying representational system is flexible and that posture identification is optimized by adapting the degree of overlap between the representations to the stimulus context (or more generally, the task at hand). A stimulus set with large orientation differences between different stimuli gives rise to more broadly tuned representations than a stimulus set with small orientation differences. Apparently, representations are more finely tuned when identification involves making finer discriminations. Representations that are smaller tuned are closer to the original stimulus and cause less generalization. By using more narrowly tuned representations, it is avoided that similar stimuli in similar orientations lead to the activation of strongly overlapping representations that make precise identification difficult.

Tuning of representations or generalization fields can be conceptualized as an adaptation (during the task) of the manner in which neurons and neuron populations are activated. When, as the task proceeds, it becomes obvious that the normal activation spreading of neuronal populations results in a larger overlap for different stimuli, a stronger criterion is set, as a result of which smaller tuning is established. In a long-term-priming experiment this adaptation primarily occurs during the priming phase. When confronted with a stimulus in the priming phase groups of neurons are tuned as a function of a number of stimulus characteristics. When during the test phase the same stimulus with the same characteristics is shown again, the identification threshold is reached faster. If, however, there is a significant change in a stimulus characteristic, partly different neurons are activated, resulting in no or less facilitation. The stimulus context (e.g., range of orientations used) probably codetermines the breadth of tuning of the neurons or the extent of activation spreading over neurons and neuron populations.

GENERAL DISCUSSION

How do observers identify human body postures? Is it the case that for all possible orientations of a body postures a single orientation-independent, object-centered memory model can be accessed in order to identify the posture (e.g., Marr and Vaina, 1982)? Or is identification accomplished via different orientation-specific representations. The results of Daems and Verfaillie (1999) and the present study support the latter hypothesis[1].

[1]Note that the link between low and high-level processing on the one hand and early and later processing mode is a hypothesis and not every researcher agrees with the link (see Sekunova et al., 2013; Brooks et al., 2016, 2018; for relevant literature in the domain of body adaptation).

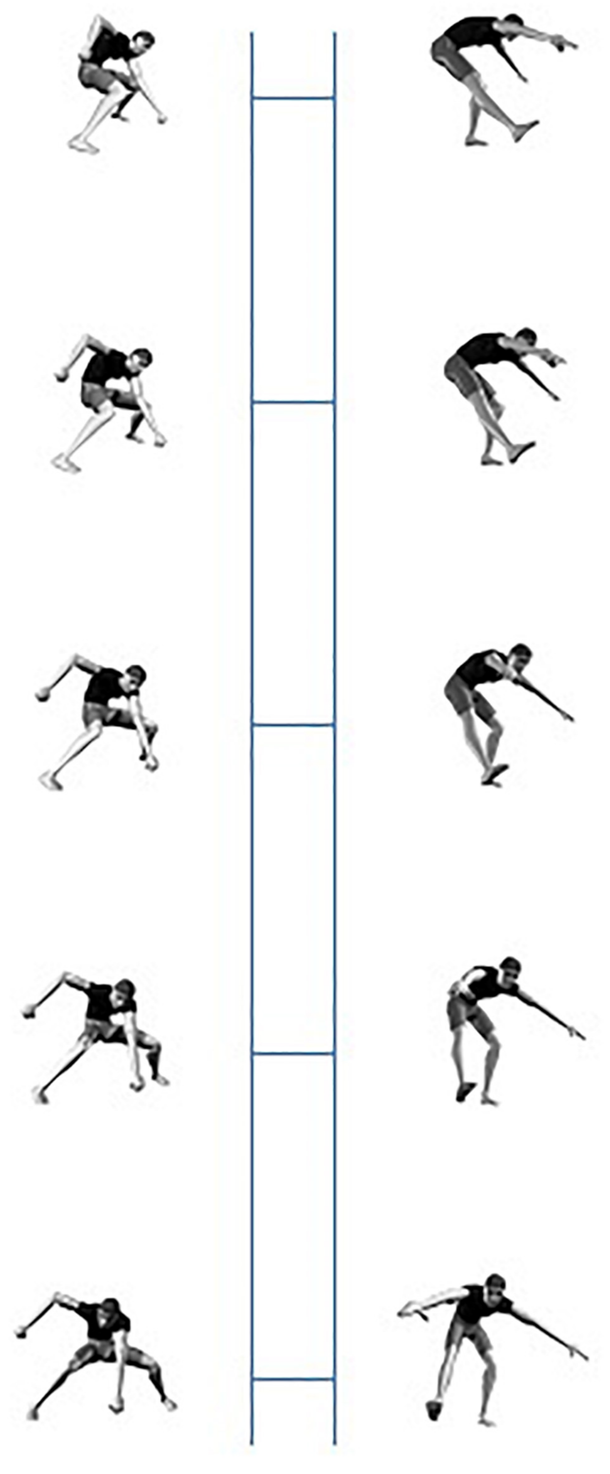

FIGURE 10 | Common representational space of two human body postures (each column depicts a particular postures in four different depth orientations; in each row two similar but distinct postures in the same depth orientation).

We were not able to directly address the inconsistency between the present Experiment 1 (i.e., priming across a 30° difference between and test posture) and research previously described by Daems and Verfaillie, 1999 (priming across a 15° difference), but through our quest to explain the difference, in Experiments 2 and 3 we were able to elucidate the flexibility of the posture representation system in the brain (e.g., relative independence of actor identity).

As already indicated, the findings in the long-term priming experiments are in line with observations on object recognition. On the one hand, this suggests that the visual system uses similar mechanisms and representations to identify objects and postures in different orientations. On the other hand, identification of body postures seems to be special. When observers are confronted with a human figure, it is probable that a general body scheme is activated that is adjusted in the correct posture and orientation. In the experiments reported in Daems and Verfaillie (1999) and Experiment 3 of the present study (in Experiments 1 and 2 the impossible postures only served as filler stimuli and were not systematically manipulated) there was no long-term priming for impossible postures. This suggests that the dynamic representations that are used for the identification of human postures are orientation specific and constrained by the biomechanical limits of the human body (also see Kourtzi and Shiffrar, 1999; Candidi et al., 2008; Cross et al., 2010; Schouten et al., 2011; Davila et al., 2014; Heenan and Troje, 2014).

Neurophysiological studies confirm the existence of a body-specific representational system (e.g., Downing et al., 2001; Peelen and Downing, 2007; Hodzic et al., 2009; Van der Wyk et al., 2009). Indeed, static pictures of human bodies activate other brain regions than images of objects. For instance, in a PET study of Peigneux et al. (2000) presentation of objects primarily resulted in activation in the occipital and fusiform gyrus, whereas body postures activated parts of the lateral occipitotemporal junction and area MT/V5.

There is evidence that region MT/V5 is strongly associated with motion perception (e.g., Howard et al., 1996), but also that it is involved in the perception of static pictures that imply motion (e.g., Peuskens et al., 2005; Urgesi et al., 2006; Pavan et al., 2011). Activation of this part of the visual cortex by the presentation of static postures probably reflects the importance of movement (even if only implied in the perception of human body postures; but see Lorteije et al., 2011). Body postures mostly are part of a movement or action sequence in which the exact position and orientation of the body as a whole and of the different body parts with respect to each other change. Integration of different postures and action phases therefore form another important component of action perception. An experiment reported by Verfaillie and Daems (2002) indeed showed that action representations are more broadly tuned in the direction of motion. On each trial in the priming phase, participants were presented with pairs of brief action animations (performed by two different human models) and had to decide whether the actions were the same or not. In the test phase subjects saw static possible or impossible postures (as in Daems and Verfaillie, 1999, and the present study). Reliable priming was observed for test postures that were preceded by a priming animation in which the figure would have reached the test posture if the priming animation would have lasted longer, but not for test postures preceded by a priming animation in which the figure would have been if the priming animation had started earlier (in comparison to a condition in which the test posture was not seen in a related priming animation). This observation indicates that movement is important to achieve generalization and anticipation to future action phases.

Some action sequences consist of changes in the global orientation of the human figure who performs the action (e.g., rotating movement as in a pirouette). In this case integration of different action phases boils down to integration of different orientations. In short-term priming experiments, it has been shown before (e.g., Kourtzi and Shiffrar, 1997, 1999; see Manera et al., 2013, for related research) that movement facilitates generalization to and anticipation of new orientations. Since human observers in daily life mostly are confronted with subsequent orientations of body postures as a result of their own movement or the movement of the observed figure, this mechanism allows identification that makes abstraction of orientation on the basis of orientation-specific representations.

In sum, the dynamic orientation-specific representations supporting posture perception are flexible and dependent on stimulus and task context. This allows the visual system to achieve a broad range of tasks. Successful identification of highly similar body postures in similar orientations probably is best supported by more finely tuned representations, whereas anticipation of future orientations and action phases (e.g., Verfaillie and Daems, 2002; Manera et al., 2013) and other tasks that are based on generalization would be more efficient with broader orientation tuning.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the Faculty of Psychology and Educational Sciences. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

Both authors contributed to framing the study theoretically, designing and executing the experiments, analyzing the data, interpreting the results, and drawing conclusion.

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REFERENCES

Alshehri, A., Bohnemeyer, J., Moore, R., and Baez, G. P. (2018). The principle of canonical orientation: a cross-linguistic study. *Lang. Cogn.* 10, 494–513. doi: 10.1017/langcog.2018.12

Ballarini, N., and Thornton, I. M. (2017). Matching biological motion across viewpoints. *Xjenza Online J. Malta Chamber Sci.* 5, 21–29.

Blake, R., and Shiffrar, M. (2007). Perception of human motion. *Annu. Rev. Psychol.* 58, 47–73.

Blanz, V., Tarr, M. J., and Bülthoff, H. H. (1999). What object attributes determine canonical views? *Perception* 28, 575–599. doi: 10.1068/p2897

Boutsen, L., Lamberts, K., and Verfaillie, K. (1998). Recognition times of different views of 56 depth-rotated objects: a note concerning Verfaillie and Boutsen (1995). *Percept. Psychophys.* 60, 900–907. doi: 10.3758/bf03206072

Brooks, A., Schouten, B., Troje, N. F., Verfaillie, K., Blanke, O., and van der Zwan, R. (2008). Correlated changes in perceptions of the gender and orientation of ambiguous biological motion figures. *Curr. Biol.* 18, R728–R729.

Brooks, K. R., Clifford, C. W. G., Stevenson, R. J., Mond, J., and Stephen, I. D. (2018). The high-level basis of body adaptation. *R. Soc. Open Sci.* 5:172103. doi: 10.1098/rsos.172103

Brooks, K. R., Mond, J. M., Stevenson, R. J., and Stephen, I. D. (2016). Body image distortion and adaptation to extreme body types: contingent adaptation and cross adaptation for self and other. *Front. Neurosci. Percept. Sci.* 10:334. doi: 10.3389/fnins.2016.00334

Brown, E. C., and Brüne, M. (2012). The role of prediction in social neuroscience. *Front. Hum. Neurosci.* 6:147. doi: 10.3389/fnhum.2012.00147

Bülthoff, H. H., Edelman, S. Y., and Tarr, M. J. (1995). How are three-dimensional objects represented in the brain? *Cereb. Cortex* 5, 247–260. doi: 10.1093/cercor/5.3.247

Candidi, M., Urgesi, C., Ionta, S., and Aglioti, S. M. (2008). Virtual lesion of ventral premotor cortex impairs visual perception of biomechanically possible but not impossible actions. *Soc. Neurosci.* 3, 388–400. doi: 10.1080/17470910701676269

Cave, C. B., Bost, P. R., and Cobb, R. E. (1996). Effects of color and pattern on implicit and explicit picture memory. *J. Exp. Psychol. Learn. Mem. Cogn.* 22, 639–653. doi: 10.1037/0278-7393.22.3.639

Chan, A. W.-R., Peelen, M. V., and Downing, P. E. (2004). The effect of viewpoint on body representation in the extrastriate body area. *Neuroreport* 15, 2407–2410. doi: 10.1097/00001756-200410250-00021

Cross, E. S., Mackie, E. C., Wolford, G., and Hamilton, A. F. (2010). Contorted and ordinary body postures in the human brain. *Exp. Brain Res.* 204, 397–407. doi: 10.1007/s00221-009-2093-x

Cutting, J. E., and Kozlowski, L. T. (1977). Recognizing friends by their walk. *Bull. Psychon. Soc.* 9, 353–356. doi: 10.3758/bf03337021

Cutzu, F., and Edelman, S. (1994). Canonical views in object representation and recognition. *Vis. Res.* 34, 3037–3056. doi: 10.1016/0042-6989(94)90277-1

Daems, A., and Verfaillie, K. (1999). Viewpoint-dependent priming effects in the perception of human actions and body postures. *Vis. Cogn.* 6, 665–693. doi: 10.1080/135062899394894

Davila, A., Schouten, B., and Verfaillie, K. (2014). Perceiving the direction of articulatory motion in point-light actions. *PLoS One.* 9:e115117. doi: 10.1371/journal.pone.0115117

de la Rosa, S., Mieskes, S., Bülthoff, H. H., and Curio, C. (2013). View dependencies in the visual recognition of social interactions. *Front. Psychol.* 4:752. doi: 10.3389/fpsyg.2013.00752

Downing, P. E., Jiang, Y., Shuman, M., and Kanwisher, N. (2001). A cortical area selective for visual processing of the human body. *Science* 293, 2470–2473. doi: 10.1126/science.1063414

Edelman, S. (1995). Class similarity and viewpoint invariance in the recognition of 3D objects. *Biol. Cybern.* 72, 207–220. doi: 10.1007/bf00201485

Edelman, S. (1999). *Representation and Recognition in Vision*. Cambridge, MA: MIT Press.

Fractal Design Corporation, (1996). *Poser [computer software]*. Aptos, CA: Fractal Design Corporation.

Gallese, V., Keysers, C., and Rizzolatti, G. (2004). A unifying view of the basis of social cognition. *Trends Cogn. Sci.* 8, 396–403. doi: 10.1016/j.tics.2004.07.002

Galton, F. (1883). *Inquiries Into Human Faculty and Its Development*. London: Macmillan.

Gauthier, I., Behrmann, M., and Tarr, M. J. (1999). Can face recognition really be dissociated from object recognition? *J. Cogn. Neurosci.* 11, 349–370. doi: 10.1162/089892999563472

Gauthier, I., and Tarr, M. J. (1997). Orientation priming of novel shapes in the context of viewpoint-dependent recognition. *Perception* 26, 51–73. doi: 10.1068/p260051

Ghose, T., and Liu, Z. (2013). Generalization between canonical and non-canonical views in object recognition. *J. Vis.* 13:1. doi: 10.1167/13.1.1

Gold, J. M., Tadin, D., Cook, S. C., and Blake, R. (2008). The efficiency of biological motion perception. *Percept. Psychophys.* 70, 88–95. doi: 10.3758/pp.70.1.88

Heenan, A., and Troje, N. F. (2014). Both physical exercise and progressive muscle relaxation reduce the facing-the-viewer bias in biological motion perception. *PLoS One* 9:e99902. doi: 10.1371/journal.pone.0099902

Hodzic, A., Kaas, A., Muckli, L., Stirn, A., and Singer, W. (2009). Distinct cortical networks for the detection and identification of human body. *Neuroimage* 45, 1264–1271. doi: 10.1016/j.neuroimage.2009.01.027

Howard, R. J., Brammer, M., Wright, I., Woodruff, P. W., Bullmore, E. T., and Zeki, S. (1996). A direct demonstration of functional specialization within motion-related visual and auditory cortex of the human brain. *Curr. Biol.* 6, 1015–1019. doi: 10.1016/s0960-9822(02)00646-2

Humphreys, G. W., and Forde, E. M. E. (2001). Hierarchies, similarity, and interactivity in object recognition: "Category-specific" neuropsychological deficits. *Behav. Brain Sci.* 24, 453–509.

Isik, L., Koldewyn, K., Beeler, D., and Kanwisher, N. (2017). Perceiving social interactions in the posterior superior temporal sulcus. *Proc. Natl. Acad. Sci. U.S.A.* 114, E9145–E9152. doi: 10.1073/pnas.1714471114

Jellema, T., and Perrett, D. I. (2003). Perceptual history influences neural responses to face and body postures. *J. Cogn. Neurosci.* 15, 961–971. doi: 10.1162/089892903770007353

Kirk, R. E. (1968). *Experimental Design: Procedures for the Behavioral Sciences*. Belmont, CA: Brooks/Cole Publishing Companay.

Kourtzi, Z., and Shiffrar, M. (1997). One-shot view invariance in a moving world. *Psychol. Sci.* 8, 461–466. doi: 10.1111/j.1467-9280.1997.tb00462.x

Kourtzi, Z., and Shiffrar, M. (1999). Dynamic representations of human body movement. *Perception* 28, 49–62. doi: 10.1068/p2870

Lawson, R., and Humphreys, G. W. (1996). View specificity in object processing: evidence from picture matching. *J. Exp. Psychol. Hum. Percept. Perform.* 22, 395–416. doi: 10.1037/0096-1523.22.2.395

Lawson, R., and Humphreys, G. W. (1998). View-specific effects of depth rotation and foreshortening on the initial recognition and priming of familiar objects. *Percept. Psychophys.* 60, 1052–1066. doi: 10.3758/bf03211939

Logothetis, N. K., Pauls, J., and Poggio, T. (1995). Shape representation in the inferior temporal cortex of monkeys. *Curr. Biol.* 5, 552–563. doi: 10.1016/s0960-9822(95)00108-4

Lorteije, J. A. M., Barraclough, N. E., Raemaekers, M., Duinhouwer, J., Xiao, D., Oram, M. W., et al. (2011). Implied motion activation in area MT can be explained by visual low-level features. *J. Cogn. Neurosci.* 23, 1533–1548. doi: 10.1162/jocn.2010.21533

Loula, F., Prasad, S., Harber, K., and Shiffrar, M. (2005). Recognizing people from their movement. *J. Exp. Psychol. Hum. Percept. Perform.* 31, 210–220. doi: 10.1037/0096-1523.31.1.210

Manera, V., Becchio, C., Schouten, B., Bara, B. G., and Verfaillie, K. (2011). Communicative interactions improve visual detection of biological motion. *PLoS One* 6:e14594. doi: 10.1371/journal.pone.0014594

Manera, V., Schouten, B., Becchio, C., Bara, B. G., and Verfaillie, K. (2010). Inferring intentions from biological motion: a stimulus set of point-light communicative interactions. *Behav. Res. Methods* 42, 168–178. doi: 10.3758/BRM.42.1.168

Manera, V., Schouten, B., Verfaillie, K., and Becchio, C. (2013). Time will show: real time predictions during interpersonal action perception. *PLoS One* 8:e54949. doi: 10.1371/journal.pone.0054949

Marr, D., and Vaina, L. (1982). Representation and recognition of the movements of shapes. *Proc. R. Soc. Lond. B Biol. Sci.* 214, 501–524. doi: 10.1098/rspb.1982.0024

Maurer, D., Le Grand, R., and Mondlich, C. J. (2002). The many faces of configural processing. *Trends Cogn. Sci.* 6, 255–260. doi: 10.1016/s1364-6613(02)01903-4

Moors, P., Germeys, F., Pomianowska, I., and Verfaillie, K. (2015). Perceiving where another person is looking: the integration of head and body information in estimating another person's gaze. *Front. Psychol. Percept. Sci.* 6:909. doi: 10.3389/fpsyg.2015.00909

Murray, J. E. (1998). Is entry-level recognition viewpoint-invariant or viewpoint-dependent. *Psychon. Bull. Rev.* 5, 300–304. doi: 10.3758/bf03212955

Newell, F. N. (1998). Stimulus context and viewpoint dependence in object recognition. *Perception* 27, 47–68. doi: 10.1068/p270047

Niemann, T., Lappe, M., and Hoffmann, K. P. (1996). Visual inspection of three-dimensional objects by human observers. *Perception* 25, 1027–1042. doi: 10.1068/p251027

Nilsson, L.-G., Olofsson, U., and Nyberg, L. (1992). Implicit memory of dynamic information. *Bull. Psychon. Soc.* 30, 265–267. doi: 10.3758/bf03330460

Palmer, S., Rosch, E., and Chase, P. (1981). "Canonical perspective and the perception of objects," in *Attention and Performance IX*, eds J. Long, and A. Baddeley, (Hillsdale, NJ: Erlbaum), 135–151.

Pavan, A., Cuturi, L. F., Maniglia, M., Casco, C., and Campana, G. (2011). Implied motion from static photographs influences the perceived position of stationary objects. *Vis. Res.* 51, 187–194. doi: 10.1016/j.visres.2010.11.004

Peelen, M. V., and Downing, P. E. (2007). The neural basis of visual body perception. *Nat. Rev. Neurosci.* 8, 636–648. doi: 10.1038/nrn2195

Peigneux, P., Salmon, E., van der Linden, M., Garraux, G., Aerts, J., Delfiore, G., et al. (2000). The role of lateral occipitotemporal junction and area MT/V5 in the visual analysis of upper-limb postures. *Neuroimage* 11, 644–655. doi: 10.1006/nimg.2000.0578

Perrett, D. I., Mistlin, A. J., and Chitty, A. J. (1989). Visual neurones responsive to faces. *Trends Neurosci.* 10, 358–364. doi: 10.1016/0166-2236(87)90071-3

Perrett, D. I., Oram, M. W., Harries, M. H., Bevan, R., Hietanen, J. K., Benson, P. J., et al. (1991). Viewer-centered and object-centered encoding of heads analysed at the single cell level in the temporal cortex of the rhesus macaque. *Exp. Brain Res.* 86, 159–173.

Peuskens, H., Vanrie, J., Verfaillie, K., and Orban, G. A. (2005). Specificity of regions processing biological motion. *Eur. J. Neurosci.* 21, 2864–2875. doi: 10.1111/j.1460-9568.2005.04106.x

Pittenger, D. J. (2003). *Behavioral Research: Design and Analysis*. New York, NY: McGraw-Hill.

Prasad, S., and Shiffrar, M. (2009). Viewpoint and the recognition of people from their movement. *J. Exp. Psychol. Hum. Percept. Perform.* 35, 39–49. doi: 10.1037/a0012728

Raffone, A., Srinivasan, N., and van Leeuwen, C. (2014). Perceptual awareness and its neural basis: bridging experimental and theoretical paradigms. *Philos. Trans. R. Soc. B* 369:20130203. doi: 10.1098/rstb.2013.0203

Reed, C. L., Nyberg, A. A., and Grubb, J. D. (2012). Contributions of visual and embodied expertise to body perception. *Perception* 41, 436–446. doi: 10.1068/p7029

Rosselli, F. B., Alemi, A., Ansuini, A., and Zoccolan, D. (2015). Object similarity affects the perceptual strategy underlying invariant object recognition in rats. *Front. Neural Circuits* 9:10. doi: 10.3389/fncir.2015.00010

Rumiati, R. I. (2000). Cognitive neuroscience of actions: a whole is greater than the sum of its parts. *Brain Cogn.* 44, 117–123. doi: 10.1006/brcg.2000.1224

Schouten, B., Troje, N. F., and Verfaillie, K. (2011). The facing bias in biological motion perception: structure, kinematics, and body parts. *Atten. Percept. Psychophys.* 73, 130–143. doi: 10.3758/s13414-010-0018-1

Sebanz, N., and Frith, C. (2004). Beyond simulation? Neural mechanisms for predicting the actions of others. *Nat. Neurosci.* 7, 5–6. doi: 10.1038/nn0104-5

Sekunova, A., Black, M., Parkinson, L., and Barton, J. J. (2013). Viewpoint and pose in body-form adaptation. *Perception* 42, 176–186. doi: 10.1068/p7265

Srinivas, K. (1993). Perceptual specificity in nonverbal priming. *J. Exp. Psychol. Learn. Mem. Cogn.* 19, 582–602. doi: 10.1037/0278-7393.19.3.582

Srinivas, K. (1995). Representation of rotated objects in explicit and implicit memory. *J. Exp. Psychol. Hum. Percept. Perform.* 21, 1019–1036. doi: 10.1037/0278-7393.21.4.1019

Tai, Y. F., Scherfler, C., Brooks, D. J., Sawamoto, N., and Castiello, U. (2004). The human premotor cortex is 'mirror' only for biological actions. *Curr. Biol.* 14, 117–120. doi: 10.1016/j.cub.2004.01.005

Tarr, M. J., and Gauthier, I. (1998). Do viewpoint-dependent mechanisms generalize across members of a class? *Cognition* 67, 73–110. doi: 10.1016/s0010-0277(98)00023-7

Urgesi, C., Moro, V., Candidi, M., and Aglioti, S. M. (2006). Mapping implied body actions in the human motor system. *J. Neurosci.* 26, 7942–7949. doi: 10.1523/jneurosci.1289-06.2006

Van Belle, G., De Graef, P., Verfaillie, K., Busigny, T., and Rossion, B. (2010a). Whole not hole: expert face recognition requires holistic perception. *Neuropsychologia* 48, 2620–2629. doi: 10.1016/j.neuropsychologia.2010.04.034

Van Belle, G., De Graef, P., Verfaillie, K., Rossion, B., and LefΠvre, P. (2010b). Face inversion impairs holistic perception: evidence from gaze-contingent stimulation. *J. Vis.* 10, 1–13. doi: 10.1167/10.5.10

Van der Wyk, B. C., Hudac, C. M., Carter, E. J., Sobel, D. M., and Pelphrey, K. A. (2009). Action understanding in the superior temporal sulcus region. *Psychol. Sci.* 20, 771–777. doi: 10.1111/j.1467-9280.2009.02359.x

Verfaillie, K., and Boutsen, L. (1995). A corpus of 714 full-color images of depth-rotated objects. *Percept. Psychophys.* 57, 925–961. doi: 10.3758/bf03205454

Verfaillie, K., and Daems, A. (2002). Representing and anticipating human actions in vision. *Vis. Cogn.* 9, 217–232. doi: 10.1080/13506280143000403

Verfaillie, K., Huysegems, S., De Graef, P., and Van Belle, G. (2014). Impaired holistic and analytic face processing in congenital prosopagnosia: evidence from the eye-contingent mask/window paradigm. *Vis. Cogn.* 22, 503–521. doi: 10.1080/13506285.2014.881446

Vrancken, L., Germeys, F., and Verfaillie, K. (2017). Holistic integration of gaze cues in visual face and body perception: evidence from the composite design. *J. Vis.* 17:24. doi: 10.1167/17.1.24

Vrancken, L., Vermeulen, E., Germeys, F., and Verfaillie, K. (2019). Measuring facial identity and emotion integration using the redundancy gain paradigm. *Atten. Percept. Psychophys.* 81, 217–236. doi: 10.3758/s13414-018-1603-y

Wang, Y., Wang, L., Xu, Q., Liu, D., Chen, L., Troje, N. F., et al. (2018). Heritable aspects of biological motion perception and its covariation with autistic traits. *Proc. Natl. Acad. Sci. U.S.A.* 115, 1937–1942. doi: 10.1073/pnas.1714.65 51.15

Willems, S., Vrancken, L., Germeys, F., and Verfaillie, K. (2014). Holistic processing of human body postures: evidence from the composite effect. *Front. Psychol. Percept. Sci.* 5:618. doi: 10.3389/fpsyg.2014.00618

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Muscles and the Media: A Natural Experiment Across Cultures in Men's Body Image

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An increasing number of studies are evidencing relationships between the drive for muscularity and potentially harmful behavioral strategies, such as unhealthy dieting and steroid use amongst men in WEIRD (Western, Educated, Industrialized, Rich, Democratic) populations. As such Western appearance standards proliferate around the world via the media, men who live in other cultural contexts are also at risk of potentially negative effects from aspiring to the "muscular ideal." However, few studies have explored these relationships in non-WEIRD populations. We investigated men's body ideals and body image in two non-WEIRD, non-White populations, Uganda (Africa) and Nicaragua (Central America), and compared them with an ethnically diverse sample of men in the United Kingdom. We also examined whether socio-cultural factors including media and ethnicity, predicted the drive for muscularity and body change behaviors among our participants. Results showed that Ugandan men had the least desire for muscularity relative to men in the United Kingdom. Supporting the Tripartite model we found that media and peer influences significantly predicted the drive for muscularity, particularly among men from White British and Nicaraguan Miskitu ethnic groups. By contrast, Creole / Garifuna and Mestizo men from Nicaragua were more likely to want to increase muscularity relative to Black African men from Uganda. Overall, our findings support previous research in demonstrating that there are cultural differences in the kind of body men desire, and that men from WEIRD and non-WEIRD populations may experience similar pressures to aspire to and attain a muscular body type.

Keywords: body image, muscularity, body ideals, cross-cultural, ethnicity

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INTRODUCTION

The often unrealistic appearance standards that proliferate Western media are believed to influence people's body ideals. "Ideal" women are portrayed as "curvaceously thin," with a low body weight but full breasts (Harrison, 2003), while "ideal" men have bodies with "worked-out" muscles and v-shaped torsos (Edwards et al., 2014). Both correlational and experimental studies have shown that even relatively short durations of exposure to the media's body ideals can have a detrimental effect on women's body image (Grabe et al., 2008). Less conclusive evidence suggests that media exposure is also associated with negative effects on men's body image (Blond, 2008; Hausenblas et al., 2013) in similar but not identical ways (Barlett et al., 2008; Tamplin et al., 2018).

As the media become ever more pervasive, and Western appearance standards are broadcast to people around the world, the need for research that measures the media's impact on body image and well-being beyond a White, Western demographic becomes more pressing. Studies show that even in non-WEIRD (that is Western, Educated, Industrialized, Rich, Democratic; see Henrich et al., 2010) populations with relatively recent exposure to Western media, television consumption is associated with slimmer female body ideals among both men and women (Jucker et al., 2017; Thornborrow et al., 2018; Boothroyd et al., 2019) and with disordered eating among women (Becker et al., 2002) and dieting behaviors (Boothroyd et al., 2016). While few studies have investigated media influence on men's body image outside of a WEIRD demographic (Edwards et al., 2014), scant evidence suggests that men in non-WEIRD populations are also beginning to aspire to the muscular ideal body type (Holmqvist and Frisén, 2010) and experience body image concerns (Ricciardelli et al., 2007a; Xu et al., 2010).

Chronic media saturation of the physical and sociocultural environment means such idealized bodies proliferate people's "visual diet" and become normalized (Boothroyd et al., 2012; Smirles and Lin, 2018). While not every individual who is exposed to media's appearance ideals will experience negative effects, those who cognitively adopt these body ideals may be at greater risk than those individuals who do not (Nouri et al., 2011). This acceptance of, and aspiration toward, an external, socially constructed appearance standard is known as internalization (Thompson and Heinberg, 1999). While there is considerable evidence that among girls and women, internalization of media's body ideals is associated with detrimental effects on body image and well-being (Grabe et al., 2008), there is less evidence of this relationship among men. Furthermore, the contributing factors, pathways and outcomes appear to be more varied, and are less well understood (Edwards et al., 2014).

As the societal body ideal for women is based on achieving and maintaining a low body weight, women's body dissatisfaction is most often associated with a drive for a thinness (although not always, see Cramblitt and Pritchard, 2013). Conversely, the societal ideal body for men demands a developed musculature (particularly the upper body) and leanness to produce a "v" shaped torso. As a consequence men's body concerns are predominantly associated with a drive for muscularity (Edwards et al., 2014), although a drive for thinness may be involved too (Pritchard and Cramblitt, 2014). Research evidence shows that men and adolescent boys are increasingly experiencing pressure to conform to the "muscular ideal" body type (Ricciardelli et al., 2007b; Waling, 2017). In the United States, 60% of adolescent boys reported engaging in muscle enhancing behaviors (Eisenberg et al., 2012). Furthermore, evidence suggests that in clinical diagnoses, the occurrence of extreme muscle enhancing behaviors are becoming as common among young men as severe weight control and purging behaviors are among young women (Murray et al., 2016; Karazsia et al., 2017; Lavender et al., 2017).

The Drive for Muscularity

The drive for muscularity can be defined as the cognitive tension between an individual's perception of their body as insufficiently muscular and the external, usually culturally-constructed muscular ideal that they believe they need to attain (Colman, 2015). A number of studies have identified associations of the drive for muscularity with actual media exposure, and with media internalization (Daniel and Bridges, 2010; Cramblitt and Pritchard, 2013; Pritchard and Cramblitt, 2014). However, although internalization in these studies significantly predicted men's drive for muscularity, relationships with actual media exposure were weaker. This could be due to the way media exposure was measured or it could indicate that other sources of societal pressure also play a role in this relationship (Pritchard and Cramblitt, 2014). For example, men's ideal body types may be more prevalent among peers or "specialist" groups such as athletes, than in mainstream media (Karazsia and Crowther, 2009).

While several studies have shown that the drive for muscularity in men is associated with body dissatisfaction and other negative psychological outcomes such as low self-esteem (Edwards et al., 2014; Girard et al., 2017), this is not always the case. For example, body builders or men who work out regularly may have a high drive for muscularity, but are also physically close to their ideal body and so may not experience body dissatisfaction (Tylka, 2011). Crucially however, even if body dissatisfaction is not present, there is strong evidence that a drive for muscularity is associated with potentially harmful body change behavioral strategies, including excessive weight training, steroid use, and unhealthy dieting behaviors (Edwards et al., 2014). This would suggest that a drive for muscularity is not qualitatively the same as the drive for thinness which is clearly associated with body dissatisfaction and disordered eating (McCreary and Sasse, 2000). Consistent with this hypothesis, men with body image disorders show a split between those who strive for thinness and those who seek to increase muscularity (McCabe and Ricciardelli, 2004; Adams et al., 2005; Barlett et al., 2008).

Most studies investigating drive for muscularity among men have sampled White men in Western populations (i.e., Australia, United States, and United Kingdom) (Ricciardelli et al., 2007b; Jung et al., 2010; Edwards et al., 2014). The limited number of studies which have sampled from outside this demographic have produced mixed findings. While Chinese males were less likely to value muscularity than United States men (Jung et al., 2010), another study found less differences between Asian American and European American men (Cheng et al., 2016). In the United Kingdom, Black and Asian men reported higher drive for muscularity than White men (Swami, 2016). Thus far, due to the low numbers of studies carried out, no consistent pattern relating to body image or drive for muscularity among non-White men in different cultural settings has been identified (Ricciardelli et al., 2007b).

Sociocultural Influences on Men's Body Image

Much of the research investigating sociocultural influences on body image has focused on media, likely because in Western contexts where most studies are carried out, mass media are the primary transmitters of societal appearance standards. However, studies in a number of countries suggest that other sociocultural influences, such as friends and family, may be more salient factors in shaping body ideals and influencing body image among adolescent boys and men (Karazsia and Crowther, 2009; Tylka, 2011; Stratton et al., 2015). For example, among Australian adolescent boys, comments from fathers were significantly associated with their exercise behaviors, and mothers were viewed as having a greater influence on the boys' body image than other sociocultural factors (Ricciardelli et al., 2000). For Turkish adolescent boys, comments from male peers predicted appearance importance, and fathers' attitudes influenced behaviors to attain a muscular ideal body (Dogan et al., 2018). Several other studies have found that boys were more likely to be influenced by appearance pressures from family, particularly in non-WEIRD populations (Mellor et al., 2008; McCabe et al., 2015).

The Tripartite Influence model (Thompson et al., 1999) is particularly useful for investigating predictors of body image related outcomes in non-WEIRD settings, where Western media (and thus media's appearance ideals) may not be so pervasive, or where cultural values are traditionally transmitted predominantly via peers or family members. The model proposes that three main sociocultural influences, family, peers and the media, are largely responsible for conveying and maintaining appearance-related standards and messages. Such sociocultural messages can impact individuals' body image and behaviors both directly, and indirectly through the processes of appearance comparison and internalization. The model has been used to predict body dissatisfaction among children (Rodgers et al., 2015), weight satisfaction and disordered eating among women (Markey, 2004), and body dissatisfaction and muscularity-enhancing behaviors among men (Karazsia and Crowther, 2009; Tylka, 2011; Stratton et al., 2015; Girard et al., 2017). However, there has been less use of a Tripartite model in non-WEIRD contexts, and research has predominantly focused on the female population.

In short, although increasing numbers of studies are evidencing relationships between the drive for muscularity and potentially harmful behavioral outcomes among men (Edwards et al., 2014), including some in non-White, non-WEIRD populations (Ricciardelli et al., 2007b), our understanding of the sociocultural influences, mechanisms and pathways involved is far from complete. As previously discussed, few studies have investigated men's body image in non-WEIRD populations. Even fewer studies have explored ethnic differences in body image and body-related behaviors within such populations: There is often a tendency to culturally "umbrella" populations within single countries (Swami, 2016). Even within supposedly culturally homogenized Western nations, body ideals and the experience of body image may vary across ethnic groups (Yanover and Thompson, 2010; Cheng et al., 2016; Swami, 2016).

The Present Study

The present study had two main aims: Firstly, we investigated men's body ideals and body image in two non-WEIRD, non-White populations, Uganda (Africa) and Nicaragua (Central America), and compared them with an ethnically diverse sample of men in the United Kingdom. Secondly, we investigated whether media exposure and other sociocultural factors, including ethnicity, predicted the drive for muscularity and body change behaviors among our participants.

Here, we provide some demographic context for Uganda and Nicaragua, firstly to demonstrate that the populations from which we drew our samples are non-WEIRD, and secondly to avoid glossing over cultural differences that may not be expressed by using nationality as the cultural indicator (Holmqvist and Frisén, 2010).

Uganda is situated in East Africa and has a population of approximately 34.6 million people. Mean life expectancy is 63.7 years and 55% of the populations are under 18 years old (Ugandan Bureau of Statistics, 2014). Uganda is an ethnically diverse country, comprising of 56 distinct tribes. Approximately 17% of indigenous people belong to the leading ethnic group, the Buganda Kingdom. Although these ethnic groups speak different languages, English is the official national language of Uganda. In terms of education, in 2014 there was an 81% Net Enrolment Rate (NER) at primary school level, 32% enrolment at secondary level and 7% in higher or further education. The country is becoming more urbanized over time. This urbanisation is mirrored by an emerging middle-class population that is expanding at a faster rate than the total Ugandan population, and is developing a more "Westernized" lifestyle and outlook (Ayoki, 2012). Uganda's Gini index is 39.5, 21.4% of the population are below the poverty line and gross national income per capita is approximately $2,400 (World Factbook, 2019). In Uganda's capital Kampala, where we recruited participants for the current study, 68.1% of households own a television and 40.2% have access to the internet (Ugandan Bureau of Statistics, 2014), and it is likely that these statistics have since increased. Additionally, the majority of the Ugandan participants were recruited from a manufacturing company, where staff have access to the internet during work hours.

Nicaragua is situated in Central America and has an estimated population of just over 6 million. Over 48% of the population are under 25 years of age and life expectancy is 73.5 years (World Factbook, 2019). The population is ethnically diverse, although a vast majority identify as Mestizo (mixed Spanish European and indigenous background). Other ethnic groups include Creole and Garifuna, who identify as of predominantly Black Caribbean and Black African descent, and Miskitu, Ulwa and Sumu, who identify as indigenous people. Individuals are often of mixed heritage but will usually align themselves with one particular ethnic group. Although the official language is Spanish, on the Caribbean coast where the present research was carried out, many people speak English Creole and Miskitu. The level of education in the country is variable but generally low relative to Western nations: for instance in our own previous research in the same region of Nicaragua, mean years of education was 6.9 (Boothroyd et al., 2019). Nearly 30% of people live below the poverty line (World Factbook, 2019). The GINI index for Nicaragua is 47.1 and gross national income per capita is around United States $5,900 (World Factbook, 2019). In our rural Nicaraguan field site, media access varied considerably depending on local electricity supply. While internet access was a theoretical possibility in villages with a phone signal, most people were not able to afford smart phones or computers, so television was the main source of visual media for this population at the time of data collection (see Boothroyd et al., 2016).

Our study aimed to address the following research questions:

Do Men in These Three Countries Have Similar Body Ideals?

Very little research on men's body ideals has been carried out in African populations, but there does appear to be a preference for larger bodies compared with those in Britain (e.g., Furnham and Baguma, 1994; Tovée et al., 2006). Nigerian and Ugandan men also desired a body similar to, or slightly larger than their own perceived body size (Maruf et al., 2012; Okoro et al., 2014). Preferences for muscularity are more ambiguous. Ariaal herdsmen in Kenya desired a more muscular body (Campbell et al., 2005), and among Hadza hunter gatherers a more developed upper body was a predictor of positive reputation (Apicella, 2014). Conversely, Ghanaian men showed the least desire for muscularity in comparison to Ukrainian and American men (Frederick et al., 2007). No studies on male bodies have been reported in Nicaragua but a study carried out in the nearby Caribbean island of St Kitts found no differences in men's ideal fat and muscularity levels relative to men in the United States (Gray and Frederick, 2012). The present study will determine whether the men in our three populations show differences in their ideal male body.

Are There Country Differences in Men's General Body Appreciation?

Previous studies have suggested there may be differences in body appreciation among men across cultural and ethnic groups (Ricciardelli et al., 2007b). For example, Black and Hispanic men in the United States displayed less body image concerns than their White compatriots (Fiske et al., 2014). We postulated that men's body appreciation would be higher among Ugandan and Nicaraguan men compared with men in the United Kingdom.

Does Men's Media Use and Internalisation Differ Between Countries?

We expected to find significant differences in TV consumption across our three populations due to differences in general media access. We further postulated that media internalisation would differ, with men in the United Kingdom showing higher internalisation than men from Uganda and Nicaragua.

What Sociocultural Factors, Including Media and Ethnicity, Predict a Drive for Muscularity, and in Turn, Does the Drive for Muscularity Predict Men's Body Goals?

There is evidence that aside from media influence, peers and family may also play a role in drive for muscularity (McCabe et al., 2015). We used a Tripartite model to examine whether these sociocultural influences predicted attitudes toward and behaviors around muscularity among men in our three countries. Furthermore, based on previous research that suggests ethnic differences in men's desire for muscularity, we also included participant ethnicity into the model. While we expected that media and peer influences would predict drive for muscularity among White men in the United Kingdom, we did not make any *a priori* prediction regarding Nicaraguan or Ugandan men.

Employing machine learning algorithms, we also explored if, in turn, muscularity-oriented attitudes and behaviors predicted the likelihood of men from different ethnic groups engaging in body change behaviors.

MATERIALS AND METHODS

Participants

Nicaragua

The lead author (TT) had been working in this region for several years on an associated project, so was very familiar with the people and the local culture. Participants were recruited to this study via word of mouth. In the two smaller communities, communal leaders were initially approached who then notified villagers of the researcher's presence and invited them to participate. In the third larger community, participants were recruited and tested by a local male research assistant trained by TT. A total of 95 men, aged from 15 to 49 (M = 24.1 years, SD = 7.86) were recruited from three communities around the Pearl Lagoon Basin. In this region of Nicaragua, a man is considered to be a man when he is able to work and provide for his family. Many men are fathers and breadwinners well before the age of 18. Therefore, as with our previous Nicaraguan studies (see Boothroyd et al., 2016; Jucker et al., 2017; Thornborrow et al., 2018; Boothroyd et al., 2019), self-identified men under the age of 18 were not prevented from taking part (n = 10). Participants self -identified as belonging to Miskitu (N = 68), Mestizo (N = 21), and Creole / Garifuna (N = 6) ethnic groups. Mean number of years in full time education was 8.9, ranging from 0 to 16 years (SD = 3.38). All methods and procedures used in Nicaragua were approved by Durham University Department of Psychology Ethics Committee, reference: 13/17.

Uganda

Co-author SM is Ugandan and collected the data in Kampala. Participants were recruited using opportuning sampling and via written invitations sent to all employees (including cleaners, security staff, factory floor workers and management) of a large pharmaceutical manufacturing company. The Ugandan sample consisted of 31 men, aged from 22 to 45 (M = 32.1 years, SD = 6.31) who belonged to 16 different ethnic groups. However, as these ethnic groups share key characteristics (i.e., Black African background and culture) and all participants were residing in the same urban environment, for the purposes of our analyses we refer to this sample as Black African. Participants had completed an average of 15.1 years of education, ranging from 10 to 22 years (SD = 2.76).

United Kingdom

Participants were recruited from staff and students using opportunity sampling at the University of Lincoln and from the general community in Lincoln and Leicester. A total of 69 male participants, aged 18 to 45 (M = 27.5 years, SD = 7.92) were recruited. Nearly two thirds of the sample (N = 45) self-identified as of a White ethnic group, and just over a third ($N = 24$) as of a Black ethnic group. The subset of Black males had been living in the United Kingdom or a similar WEIRD country for an average of 10.8 years, ranging from 2 to 30 years ($SD = 5.45$). The number of years in education varied from 6 to 28 years across the sample ($M = 16.8$ years, $SD = 3.34$).

Measures

Demographic Information, Media Exposure and Anthropometrics

Participants self-reported their age, nationality, ethnicity, years of completed full-time education, whether they watched television and, if so, the number of hours they spend watching television in an average week. In the United Kingdom, participants reported all visual media viewed including television, online, Netflix, etc., Participants' height (cm), weight (kg), chest circumference (cm), and waist circumference (cm) were measured to calculate body mass index (BMI; weight divided by height squared) as an index of body size, and waist-to-chest ratio (WCR; waist circumference in cm divided by chest circumference in cm) as a measure of upper body shape.

Men's Perceived and Ideal Body

The Male Adiposity and Muscularity Scale (MAMS) was created and utilized to specifically determine participant's perceived level of muscularity of their current body and their ideal body (see **Figure 1**). The scale consists of ten computer-generated but realistic images of an ethnically non-White male that vary only by their degree of adiposity or muscularity with all other features remaining identical. The bodies were created in Daz Studio 3D figure modeling software[1] using the Genesis 2 male model and the Genesis 2 body morphs. In five images the bodies increase in adiposity and represent a range of WCR ratios between 0.85 and 1.01, and five images increase in muscularity and represent WCR ratios between 0.65 and 0.80. Lower WCR values represent a more "v-shaped" torso. Although the scale was primarily designed to measure body perceptions relating to body shape and muscularity, it can also be utilized to assess perceptions of general body size.

General Body Appreciation

Men's general satisfaction with their bodies was measured using the Body Appreciation Scale-2 (BAS-2; Tylka and Wood-Barcalow, 2015). This 10-item scale is rated on a 5-point Likert scale (1 = never, 5 = always), with higher overall or average scores signifying a more positive general body appreciation. It has been used with women and men in both Western and non-Western populations (Tiggemann, 2015; Góngora et al., 2020). A Latin Spanish translation of the scale was constructed for the Nicaraguan part of the study. This version has since been validated (see Góngora et al., 2020). The present sample demonstrated excellent internal reliability (Cronbach's $\alpha = 0.93$).

Media Belief

Belief in media's appearance ideals (internalisation) was measured using the Sociocultural Attitudes Toward Appearance Questionnaire-3 (SATAQ-3; Thompson et al., 2004). The scale consists of a total of 30 items rated on a 5-point Likert scale (1 = disagree strongly, 5 = agree strongly). SATAQ-3 has been used in Western (Karazsia and Crowther, 2009; Sánchez-Carracedo et al., 2012) and in non-Western populations (Becker et al., 2011; Chang et al., 2013). In Nicaragua, we also employed the validated Spanish translation of the questionnaire (Sánchez-Carracedo et al., 2012). As there were no magazines at the time of data collection, and the negatively worded statements caused confusion for our rural Nicaraguan participants, we used a modified version of the scale that did not include those items. Participants in the United Kingdom and Uganda responded to all 30 items, but we only used the same 18 items as in the modified version for the analyses. The Cronbach's alpha for the 18 items in the current sample was excellent ($\alpha = 0.90$).

Drive for Muscularity

We employed McCreary and Sasse's (2000) Drive for Muscularity Scale (DMS) to measure drive for muscularity. Participants rated 15 items on a 6-point Likert scale, where 1 = never and 6 = always. There are two subscales which assess an attitudinal desire for increased muscle mass (referred to herewith as DMSAtt), and engagement in muscularity-enhancing behaviors (here referred to as DMSBeh). Men tend to score more highly on the scale than women, confirming general gender differences in the salience of the muscular body type (Swami, 2016). In Nicaragua, we also utilized the validated Spanish translation of the questionnaire (Sepulveda et al., 2015). The present sample yielded good reliability ($\alpha = 0.86$).

Body Goals

Men were asked if they were currently trying to lose weight, not trying to change their body weight, trying to gain weight in general, or trying to increase muscle. Participants were allowed to choose more than one option. One Nicaraguan participant said he wanted to lose weight but gain muscle. As this implies desire for lean muscularity, he was coded as "trying to increase muscle."

Family and Peer Influence

Two items from the Perceived Sociocultural Pressures Scale (PSPS; Rohde et al., 2017) were used to assess perceived pressures

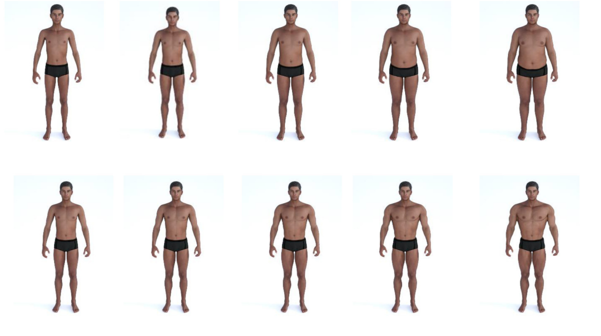

FIGURE 1 | Male Adiposity and Muscularity Scale (MAMS) The images on the top panel depict increase in adiposity The lower panel images depict a comparable increase in Muscularity.

[1] www.Daz3D.com

from friends ("I've noticed a strong message from my friends to have a muscular body") and family ("I've noticed a strong message from my family to have a muscular body"). Participants responded using a 5-point Likert rating scale where 1 = never and 5 = always. These two items were translated into Spanish by the lead author (TT). Back translations were made by a bi-lingual Colombian graduate student and then checked by a Nicaraguan school teacher to ensure suitability for a rural Nicaraguan population.

Procedure

A similar protocol was used for data collection in all three countries. Participants took part individually in a quiet room with a desk. Nicaraguan participants were offered the choice of participating in English or Spanish. In this sample, 53.6% ($n = 51$) participants took part in Spanish. Nicaraguan participants who were under 16 years were tested with a guardian present.

In Nicaragua and Uganda, all demographic and media exposure information was provided verbally by participants, whereas in the United Kingdom sample, this information was provided through written response. Firstly, anthropometric measurements were taken, asking participants to remove footwear and any bulky clothing. Individuals were given the opportunity to take their own body measurements with guidance if they preferred. Next, the MAMS images were presented on a table in a random order, in two rows of five. Participants were asked to select the image that most closely resembled their current body, followed by their desired body. Participants then responded to the following questionnaires: SATAQ-3, PSPS, BAS-2 and the DMS. All questionnaires were provided in the English language in the United Kingdom and in Uganda. In Nicaragua participants were given the option of English or Spanish versions. The entire data collection process took approximately 30 to 45 min per participant. Nicaraguan participants received a payment of £2.50 in local currency for their time. Participants in the Ugandan and United Kingdom samples did not receive any compensation for their time.

DATA HANDLING AND ANALYSES

As we were interested to ascertain men's perceptions relating to muscularity rather than simply body size, scoring for participants' ideal and perceived muscular body selected from the MAMS images was as follows. If a participant picked a body from any of the adipose images, they were given a score of 0 (not a muscular body type). If the least muscular body from the muscularity images was selected, this was coded 1, and so on, with the most muscular body coded as 5. To measure participants' perceived body size, the same perceived body selected was then coded according to its position on the scale (i.e., 1–5) regardless of adiposity or muscularity.

Item scores for each questionnaire were averaged to obtain a mean score for each participant for body appreciation (BAS-2), media belief (SATAQ), and drive for muscularity (DMS). Country comparisons of means were carried out using one-way between-subject ANOVAs. A criterion of $p < 0.05$ was used for all analyses, and where appropriate, Tukey corrected *post hoc* tests were used for *post hoc* comparisons whilst adjusting for family-wise errors.

Spearman rho correlations were performed to examine the relationships between all main variables. Two separate multiple linear regressions were conducted to ascertain whether sociocultural factors including media and ethnicity predicted men's muscularity-oriented attitudes (DMSAtt) and behaviors (DMSBeh).

To examine whether a drive for muscularity, sociocultural influences (family, friends, and media) and ethnicity can predict body change behaviors in men, we performed a multinomial logistic regression using body goals as the criterion variable. We used a cross validation approach (James et al., 2013) to split the dataset repeatedly into a training set (80%) used to train (i.e., build) the model and a test set (20%), to validate the prediction of the model. To examine whether the type of prediction analysis affected classification, we used different machine learning classifiers: K-nearest neighbour- (KNN), Random Forests (Breiman, 2001; Rokach and Maimon, 2015), and decision tree to find out which method has the best predictive accuracy based on the yet unseen data set. Although these methods assume the data to be independent, violations of this requirement were not grave in the present application, since our main aim was to assess how well a given model based on measures of sociocultural influences and ethnicity could predict weight status in a set of unseen data (Bali et al., 2016). For this, we applied a 20-fold cross validation to evaluate and supervise the training of the models. All analyses were conducted in R studio computing environment using relevant packages (R Studio Team, 2016).

RESULTS

Country Comparisons of Main Variables

Means and standard deviations for the main variables for the whole sample are presented in **Table 1**.

Men's Actual Body Size and Shape

The density distributions and means of men's waist-to-chest ratio (WCR) and body mass index (BMI) by country are presented in **Figures 2A,B**. Men from the three countries differed on WCR, $F(2,192) = 3.72$, $p = 0.026$, $\eta^2 = 0.037$, with Ugandan men having a less "v" shaped body than men in the United Kingdom and Nicaragua, as indicated by a higher WCR (all $ps \leq 0.049$). There was no statistically significant difference between United Kingdom and Nicaraguan men ($p = 0.974$). There was also a significant difference in participant BMI across the three countries, $F(2,192) = 5.64$, $p = 0.004$, $\eta^2 = 0.055$, with men in the United Kingdom having a higher BMI than men from Nicaragua ($p = 0.003$). There were no other significant differences (all $ps > 0.3$).

Men's Body Appreciation (BAS)

The density distributions and means of general body appreciation (BAS scores) by country are shown in **Figure 3**. Mean BAS score was highest in the Nicaraguan sample (45.4 ± 0.37,

TABLE 1 | Means, standard deviations, of main variables and their Spearman's rank correlations with confidence intervals.

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. TV Hours	13.69	11.08									
2. MAMS-IM	2.35	1.58	0.21**								
			[0.07, 0.34]								
3. BAS	41.76	8.15	−0.24**	−0.23**							
			[−0.37, −0.10]	[−0.36, −0.09]							
4. SATAQ	55.71	21.43	0.16*	0.30**	−0.32**						
			[0.02, 0.30]	[0.16, 0.42]	[−0.44, −0.19]						
5. DMSAtt	22.32	9.96	0.17*	0.23**	−0.04	0.39**					
			[0.03, 0.30]	[0.09, 0.36]	[−0.18, 0.10]	[0.26, 0.50]					
6. DMSBeh	15.71	9.45	0.33**	0.35**	−0.43**	0.50**	0.35**				
			[0.20, 0.45]	[0.22, 0.47]	[−0.54, −0.31]	[0.38, 0.60]	[0.22, 0.47]				
7. BMI	23.90	3.91	0.02	0.10	−0.12	0.04	−0.05	0.17*			
			[−0.12, 0.16]	[−0.05, 0.23]	[−0.25, 0.03]	[−0.10, 0.18]	[−0.19, 0.09]	[0.03, 0.30]			
8. WCR	0.90	0.09	−0.02	−0.17*	0.16*	−0.26**	−0.18*	−0.17*	0.24**		
			[−0.16, 0.12]	[−0.30, −0.03]	[0.02, 0.30]	[−0.39, −0.12]	[−0.31, −0.04]	[−0.30, −0.03]	[0.11, 0.37]		
9. MAMS-PS	2.07	1.10	0.05	0.18*	−0.12	0.07	−0.02	0.25**	0.64**	0.12	
			[−0.09, 0.19]	[0.04, 0.31]	[−0.25, 0.02]	[−0.07, 0.21]	[−0.16, 0.12]	[0.11, 0.38]	[0.55, 0.72]	[−0.02, 0.26]	
10. MAMS-PM	0.95	1.18	−0.00	0.02	0.07	0.03	0.16*	0.17*	−0.09	−0.22**	0.25**
			[−0.14, 0.14]	[−0.12, 0.16]	[−0.07, 0.21]	[−0.11, 0.17]	[0.02, 0.30]	[0.03, 0.30]	[−0.23, 0.05]	[−0.35, −0.08]	[0.11, 0.38]

*M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. *p < 0.05; **p < 0.01. TV Hours, Media use; MAMS-IM, Ideal muscular body; BAS, Body appreciation scale; SATAQ, media belief; DMSAtt, Drive for muscularity – attitude subscale; DMSBeh, Drive for muscularity- behavior subscale; BMI, Body mass index; WCR, waist-to-chest ratio; MAMS-PS, Perceived body size; MAMS-PM, Perceived muscularity.*

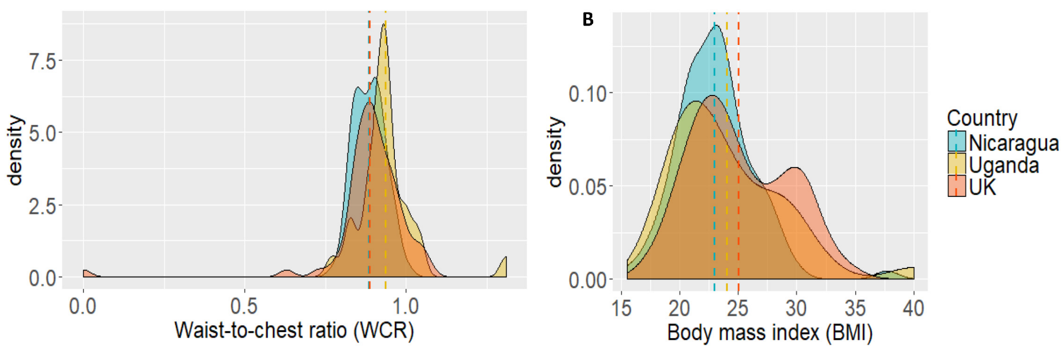

FIGURE 2 | Density of WCR **(A)** and BMI **(B)** by country. The dashed line represents the mean for each country.

Mean ± SEM), lowest for the United Kingdom sample (36.1 ± 0.64), with Ugandan sample mean being intermediate (43.2 ± 0.48). There was a significant main effect of country, $F(2,192) = 36.23$, $p < 0.001$, $\eta^2 = 0.273$. Tukey *post hoc* tests showed that BAS scores were significantly lower in the United Kingdom than both Nicaragua ($p < 0.001$) and Uganda ($p < 0.001$), who did not differ from each other ($p = 0.280$).

Men's Media Use and Media Belief

Figures 4A,B plot density distribution and means for media use (TV Hours) and media belief (SATAQ scores) as a function of country. Mean media use, measured as hours per week TV, was higher in the United Kingdom (21 ± 1.13) than Uganda (13.8 ± 0.77) and Nicaragua (9.28 ± 0.58). As expected, there was a significant main effect of country, $F(2,192) = 19.8$, $p < 0.001$, $\eta^2 = 0.171$, with men in the United Kingdom watching more TV than those in Uganda and Nicaragua (all $ps \leq 0.014$), who did not differ from each other ($p = 0.150$, **Figure 4A**).

Similarly, there was a significant main effect of country for mean SATAQ scores, $F(2,187) = 3.26$, $p = 0.041$, $\eta^2 = 0.034$, with men in the United Kingdom having greater belief in media than those from Uganda ($p = 0.048$). Nicaraguan men were intermediate but not significantly different from either (all $ps > 0.1$, **Figure 4B**).

Men's Desired and Perceived Muscularity

Figure 5 shows density distribution and mean muscular ideal body (MAMS-IM) of all three countries. Country means were: United Kingdom, 2.65 ± 0.08; Uganda, 1.77 ± 0.12; and Nicaragua, 2.32 ± 0.13. Again, there was significant main effect of country, $F(2,192) = 3.41$, $p = 0.035$, $\eta^2=0.034$,

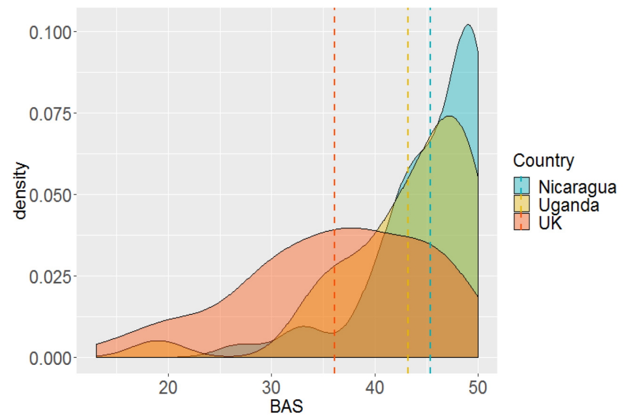

FIGURE 3 | Density of general body appreciation (BAS) by country. Dashed lines represents country means.

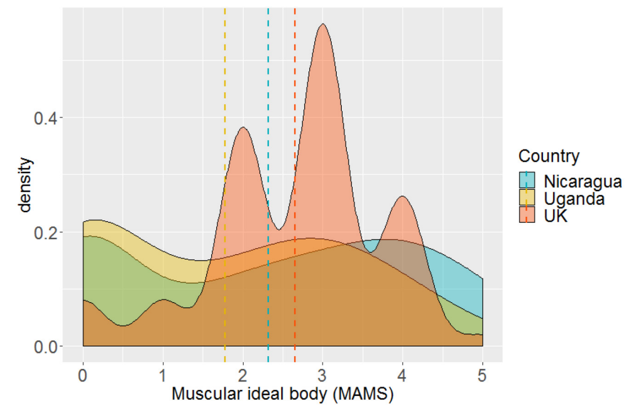

FIGURE 5 | Density distribution of muscular ideal body (MAMS) by country Dashed lines represent country means.

with men in the United Kingdom desiring a more muscular body than Ugandan men (p = 0.027). Nicaraguan men were intermediate but not significantly different from either (all $ps > 0.2$).

For perceived body size (MAMS-PS, **Figure 6A**), men in the United Kingdom perceived themselves as larger than Nicaraguan men, $F(2,192) = 4.73$, $p = 0.009$, $\eta^2 = 0.047$, *post hoc* $p = 0.008$. Ugandan men's perceived body size was intermediate but not significantly different from either group ($ps \geq 0.303$). however, there were no significant differences between the three samples for perceived muscularity (MAMS-PM, **Figure 6B**): United Kingdom, 0.97 ± 0.08; Uganda, 0.94 ± 0.09; and Nicaragua, 0.94 ± 0.09; $F(2,192) = 0.02$, $p = 0.981$, $\eta^2 = 0.001$.

Figure 7 plots density distribution and mean drive for muscularity (DMS) by country. Mean DMS scores for the three countries were: United Kingdom, 43.1 ± 1.07; Uganda, 35.1 ± 1.09; and Nicaragua, 37.3 ± 0.91. Men in the United Kingdom had greater drive for muscularity than men from Uganda and Nicaragua, $F(2,185) = 4.78$, $p = 0.009$, $\eta^2 = 0.049$ (all $ps \leq 0.027$) who did not differ from each other ($p = 0.735$).

Associations Between Men's Body Perceptions, Drive for Muscularity and Sociocultural Factors

Table 1 shows the means, standard deviations of the main variables and their correlations with confidence intervals. MAMS-IM was significantly and positively correlated with TV hours, SATAQ, DMSAtt, DMSBeh, and MAMS_PS. Perceived body size (MAMS-PS) and men's actual measured bodies (BMI) were also positively correlated (see **Table 1**), confirming the MAMS as a reliable measure of body size as well as muscularity.

Sociocultural Predictors of the Drive for Muscularity

To ascertain what factors predicted men's attitudes and behaviors around a drive for muscularity, we ran two separate multiple

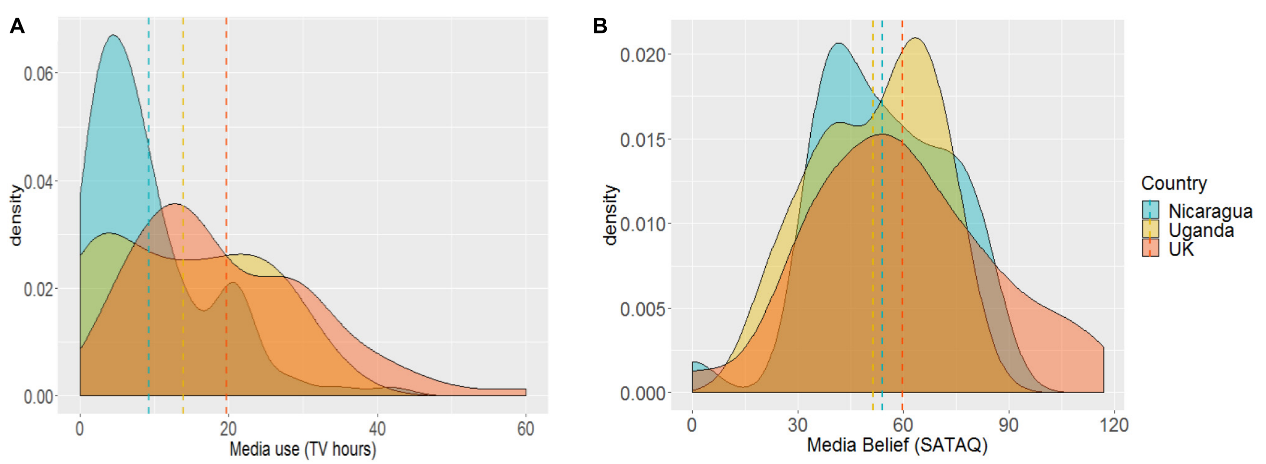

FIGURE 4 | Density of Media Use TV (Hours) **(A)** and Media Belief (SATAQ scores) **(B)** by country. Dashed lines represents country means.

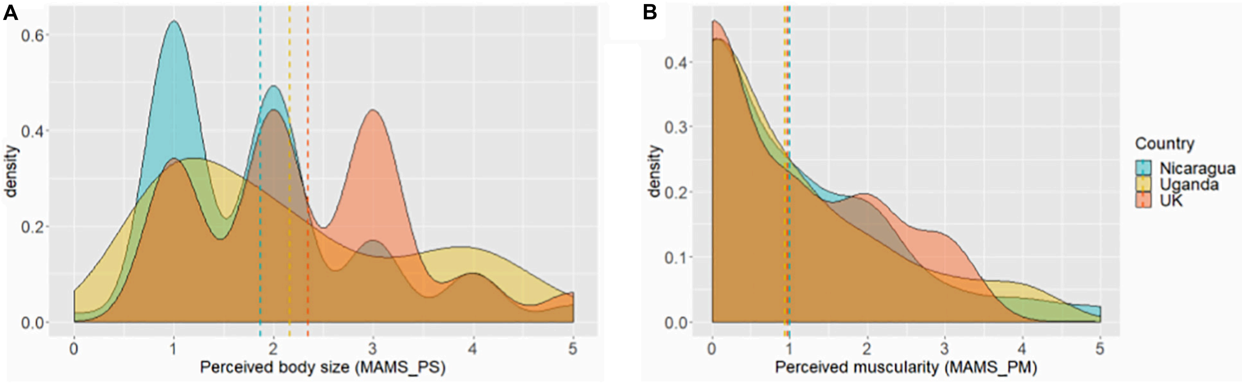

FIGURE 6 | Density of perceived body size (MAMS-PS) **(A)** and perceived Muscularity (MAMS-PM) **(B)** by country. Dashed lines represent country means.

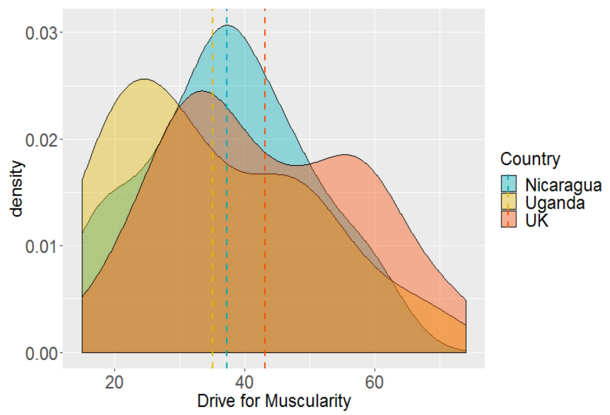

FIGURE 7 | Density distribution of Drive fro Muscularity (DMS) by Country. Dashed lines represents country means.

linear regression using the Attitude (DMSAtt) and Behavior (DMSBeh) subscales of the drive for muscularity scale (DMS) as the criterion variables. Following a Tripartite model, we entered 3 measures of sociocultural influences – family, friends (PSPS), and media belief (SATAQ) as predictor variables. As we further postulated that there may be higher drive for muscularity in some ethnic groups (i.e., White British) and we did not know if there would be differences between the other ethnic groups, we also entered participant ethnicity into the model. **Table 2** shows the regression coefficients and model summary statistics.

For the DMSAtt, the regression model was significant [$F(8,182) = 7.79$, $p < 0.001$], with an R^2 of 0.26. Friends ($\beta = 2.11$, $p < 0.001$) and media belief ($\beta = 0.07$, $p = 0.036$) contributed significantly to the model. Also, belonging to White British ($\beta = 4.54$, $p = 0.029$) and Miskitu ($\beta = 4.74$, $p = 0.011$) ethnic groups significantly predicted scores on the attitudinal component of the drive for muscularity.

For DMSBeh, the regression model was also significant [$F(8,179) = 23.89$, $p < 0.001$], with an R^2 of 0.52. Of the sociocultural influences, only media belief ($\beta = 0.13$, $p < 0.001$) contributed significantly to the model. Again, belonging to White British ($\beta = 9.74$, $p < 0.001$) and Miskitu ($\beta = -4.21$, $p = 0.004$) ethnic groups significantly predicted scores on the behavioral component of the drive for muscularity.

Can an Individual's Body Goal Be Predicted by the Drive for Muscularity and Sociocultural Factors, Including Media and Ethnicity?

To find out what factors predicted men's body goal, we conducted a multinomial logistic regression using drive for muscularity subscales attitudes (DMSAtt) and behaviors (DMSBeh), ethnicity, measures of sociocultural influences – family, friends, and media belief, as predictor variables. **Table 3** shows the model coefficients and associated p-values. "Not trying to increase" was used as the reference category. This category combined participant responses of "trying to lose weight" and "not trying to change weight". Thus, the coefficients compared "Not trying to increase" with "Trying to increase weight," and with "Trying to increase muscles."

For the predictor variable drive for muscularity attitudes subscale (DMSAtt), the log odds of body goal with "Trying to increase weight" versus "Not trying to increase" will increase by 0.141 ($p < 0.001$) whilst a one unit increase in DMSAtt will increase the log odds of "Trying to increase muscles" versus "Not trying to increase " will increase by 0.087 ($p = 0.035$). A one-unit change in media belief decreased the log odds of body goal with "Trying to increase weight" versus "Not trying to increase" by −0.048 ($p = 0.011$). Compared with the Black African ethnic group (the reference category), belonging to the Black Creole /Garifuna ethnic group decreased the log odds of body goal with "Trying to increase weight" versus "Not trying to increase" by −14.062 ($p < 0.001$) whilst the log odds of body goal with "Trying to increase muscles" versus "Not trying to increase" is increased by 3.062 ($p = 0.034$). The log odds of body goal with "Trying to increase muscles" versus "Not trying to increase" will increase if belonging to the Mestizo ethnic group by 2.584 ($p = 0.043$).

Overall, the multinomial regression analysis suggests that body goals can be predicted by belief in media, drive for muscularity (attitudinal dimension) and belonging to certain ethnic groups. Our analysis showed that Black Creole/Garifuna

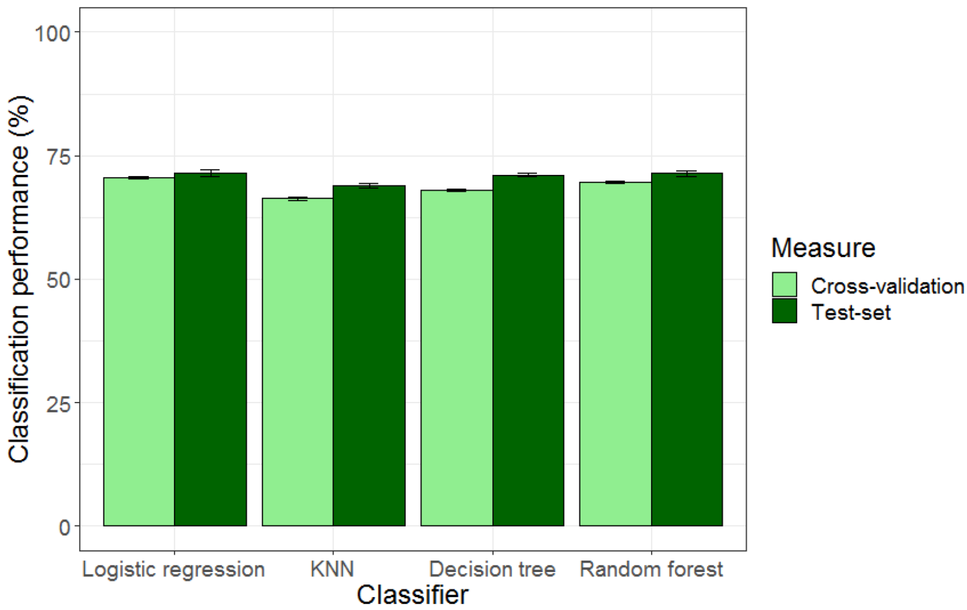

FIGURE 8 | Model predictive accuracy across several classifiers for 20-fold cross-validation (80%) and test set (20%).

TABLE 2 | Regression coefficients and model summary.

	Dependent variable			
	Drive for muscularity (Attitude)		**Drive for muscularity (Behavior)**	
	(1)		**(2)**	
	Estimate	***SE***	**Estimate**	***SE***
Family	0.519	(0.589)	0.294	(0.455)
Friends	2.102***	(0.524)	0.771*	(0.408)
Media belief	0.074**	(0.035)	0.128***	(0.028)
Ethnicity (ref: Black African)				
White British	4.537**	(2.064)	9.743***	(1.597)
Black British	2.740	(2.295)	2.294	(1.838)
Miskitu	4.740**	(1.852)	−4.209***	(1.430)
Mestizo	0.808	(2.422)	−1.770	(1.871)
Black Creole/Garifuna	4.770	(3.748)	2.853	(2.895)
Constant	9.153***	(2.301)	5.488***	(1.789)
Observations	191		188	
R^2	0.255		0.516	
Adjusted R^2	0.222		0.494	
Residual Std. Error	8.389 (df = 182)		6.478 (df = 179)	
F Statistic	7.794*** (df = 8; 182)		23.866*** (df = 8; 179)	

$^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

TABLE 3 | Regression coefficients and standard error on the outcome variable (body goal).

	Dependent variable			
	Trying to increase weight		**Trying to increase muscles**	
	(1)		**(2)**	
	Estimate	***SE***	**Estimate**	***SE***
Friends	0.024	(0.217)	0.265	(0.212)
Family	0.099	(0.247)	−0.130	(0.219)
SATAQ	−0.048**	(0.019)	−0.013	(0.017)
Ethnicity (ref: Black African)				
Black British	−0.157	(0.991)	−0.223	(1.573)
Black Creole/Garifuna	−14.062***	(0.00000)	3.062**	(1.445)
Mestizo	−0.243	(1.150)	2.584**	(1.279)
Miskitu	0.482	(0.798)	1.809	(1.155)
White British	−1.742	(1.303)	−0.276	(1.326)
DMSAtt	0.141***	(0.035)	0.087**	(0.034)
DMSBeh	−0.012	(0.046)	0.078*	(0.042)
Constant	−2.386**	(1.076)	−5.911***	(1.537)
Akaike Inf. Crit.	237.829		237.829	

$^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

and Mestizo men are more likely to want to actively increase their body's muscularity. Furthermore, Black Creole/Garifuna men are less likely to want to increase general body weight.

The confusion matrix is presented in **Table 4** and illustrates how accurate the model predicts the correct classes in the test data. The overall model accuracy for the training dataset is 71%. When the model was applied to yet unseen data, the accuracy improved to 72%, indicating no overfitting in the training dataset.

Figure 8 shows classification performance for different machine learning classifiers. Logistic regression yielded the best classification accuracy of 71.4%, while Random forests, and Decision Tree, and KNN achieved accuracies of 71.3, 71, and 69% respectively.

TABLE 4 | Confusion matrix showing the proportion of correct and incorrect predictions broken down by body goal (Test data).

		Predicted		
Actual	**WO**	**W1**	**W2**	**Total**
WO	29	1	0	30
W1	2	1	1	4
W2	3	0	1	4
Total	34	2	2	**38**

The diagonal shows the number of observations that have been correctly predicted. ***W0*** *= "Not trying to increase."* ***W1*** *= "Trying to increase weight."* ***W2*** *= "Trying to increase muscles."*

DISCUSSION

The present study investigated media influence on men's body image in two non-White, non-WEIRD populations in two of the most understudied regions of the world, Africa and Central America. We compared the body ideals and body image of ethnically diverse samples of men in Nicaragua, Uganda, and the United Kingdom. Using a Tripartite framework, we further investigated the role of ethnicity, media and other sociocultural influences in predicting men's drive for muscularity and in turn, their body change behaviors.

Country Comparisons of Men's Body Ideals and Body Image

We found significant country level differences in men's ideal body. Men in the United Kingdom had a significantly more muscular ideal body than Ugandan men who showed the lowest desire for a muscular body. This is consistent with results from Frederick et al.'s (2007) study which found that Ghanaian men had less desire for a muscular body than men in the United States and Ukraine. The authors suggested that as Ghanaian men already have more muscle they may already be much nearer to their ideal body. The Nicaraguan men's ideal body was not significantly less muscular than that of the men in the United Kingdom which is consistent with research which found that Black Caribbean men and men in the United States preferred a similarly muscular body (Gray and Frederick, 2012). Country differences in the drive for muscularity followed a similar pattern to differences in ideal muscularity, with Ugandan men having the least drive for muscularity compared with men in the United Kingdom.

There were also some significant country differences in participant body shape and size that partly reflected the differences found in men's body ideals. The Ugandan participants had a significantly less "v" shaped body than the men in the United Kingdom and Nicaraguan participants, but there was no difference between countries for participant BMI. The differences in participants' actual body shapes in the three countries may reflect differences in diet and lifestyle (Miller et al., 1990; Nelson and Tucker, 1996; Verheggen et al., 2016). For example, the Nicaraguan men in our rural sample are likely to be more physically active and have a different diet as compared to the men in the United Kingdom (Jucker et al., 2017). Additionally, different ethnic groups have different patterns of fat distribution on their body (Wells et al., 2008, 2012) and as a result, may have different body shapes and/or BMI cut-offs for health (Wildman et al., 2004; Lear et al., 2010). For example, the boundary for the overweight category is 23 and not 25 for people of Chinese or Indian descent (Choo, 2002; Shiwaku et al., 2004; Kesavachandran et al., 2012). This has implications for what is perceived as a healthy or desirable body size and shape. Many studies have argued that ideal body size and shape reflect what is perceived to be the healthiest and fittest size and shape for a particular environment (Thornhill and Grammer, 1999; Tovée et al., 2006). Thus, it is possible that the ideal body size and shape might differ across ethnic groups reflecting general differences in physiology.

Body appreciation was on average significantly higher among Nicaraguan and Ugandan men than in men in the United Kingdom. Previous comparisons of body appreciation within Western contexts have found higher levels of body appreciation and satisfaction among ethnic minority groups which may suggest a degree of cultural "shielding" from mainstream Western ideals (Wildes et al., 2001; Rodgers et al., 2018). Interestingly, the Nicaraguan men's mean BAS scores were higher than those of Mexican, Colombian and Argentinian adolescents (Góngora et al., 2020). There are factors that differentiate Nicaragua from these countries, and which may explain these differences. Firstly, Mexico and Argentina could be considered closer to WEIRD populations in many respects. Even if not strictly "Western," they are influenced by White United States and European cultural identities so people may aspire to more Western appearance standards (Meehan and Katzman, 2001). Indeed, research among women from Argentina and Brazil has found that their appearance satisfaction was similarly low to that of United States women (Forbes et al., 2012). Secondly, participants in the aforementioned studies were more likely to be of Spanish European background, while the majority of our Nicaraguan participants were from ethnic groups with Indigenous and Black African backgrounds: Research suggests that men from non-White ethnic groups often have higher body satisfaction than Hispanic or White men (Ricciardelli et al., 2007b; Kelly et al., 2015).

Sociocultural Predictors of the Drive for Muscularity and Body Change Behaviors

Across the sample, there were significant associations between media measures and men's body image, such that more TV viewing and greater media internalisation were associated with both a more muscular ideal body and lower general body appreciation, consistent with previous research in Western (Morrison et al., 2003; Cramblitt and Pritchard, 2013; Pritchard and Cramblitt, 2014) and non-Western populations (Chang et al., 2013). This permitted us to use linear regression models based on a Tripartite influence model to examine which sociocultural factors, including media, predicted men's drive for muscularity. As in previous studies using a Tripartite framework (Girard et al., 2017), we found that sociocultural influences media belief and peers significantly predicted men's attitudinal drive for muscularity. Media belief alone predicted scores on the behavioral dimension of the scale. There were also differences across ethnic groups. Belonging to a Black African or Black Creole/Garifuna ethnic group was not associated with a higher drive for muscularity. This is consistent with a study which suggested that Black Caribbean men did not have a higher desire for muscularity than an ethnically mixed United States sample (Gray and Frederick, 2012). By contrast, another study found that in the United Kingdom, Black men had higher drive for muscularity than White men (Swami, 2016). The author suggested that this may because Black British men appropriate their muscularity as a way of negotiating power inequalities, or because they have internalized Western stereotyped tropes of Blackness that emphasise the physicality or "athleticism" of the black male body (Swami, 2016). However, in the same study, stronger identification with traditional cultural values among all participants was associated with lower drive for muscularity, suggesting that men who maintain their own cultural or ethnic group identity may feel less inclined to conform to mainstream (i.e., White) appearance standards (Swami, 2016). Our results would seem to support these contrasting findings: ethnically Black men from the non-White, non-WEIRD nations sampled demonstrated less desire to strive for a muscular ideal body type than those who live in a predominantly White, Westernized nation, possibly because they experience less pressure to aspire to both Western body ideals and stereotyped constructions of Black masculinity.

To further investigate whether a drive for muscularity, family, friends and media could predict likelihood of engaging in body change behaviors, we used multinomial logistic regression and applied machine learning classifiers to evaluate how well a given model could predict body goals in a set of yet unseen data. We found that men's body goals could be predicted by greater belief in media, high drive for muscularity (attitudinal dimension) and belonging to certain ethnic groups. Importantly, we found that Black Creole/Garifuna and Mestizo men were more likely to want to increase muscularity compared to Black African men. Furthermore, Black Creole / Garifuna men were less likely to want to increase general body weight. It is interesting to note that although Black Creole / Garifuna men were more likely to report a body goal of trying to increase their muscle than both Black British and Black Ugandan men, belonging to Black Creole / Garifuna ethnic groups was not associated with a drive for muscularity, i.e., these men did not appear to feel psychological pressure to achieve a muscular body type. Previous studies looking at body size concerns among Black males have also produced mixed findings. In the United States, Black men had either higher body satisfaction than other ethnic groups or were no different from the other groups. However, Black adolescents have high levels of unhealthy weight control behaviors and dieting (e.g., Doris et al., 2015; Kelly et al., 2015; Rodgers et al., 2017).

Mechanisms Explaining Sociocultural Influences on Men's Body Image

Differences in body ideals can potentially arise due to a change in the size or shape of the bodies an individual is viewing (i.e., a change in their visual diet). This is because it is hypothesized that we judge bodies with reference to an internal template, which is based on all the bodies we have seen over the course of our lifetime with a bias toward the most recently viewed (Winkler and Rhodes, 2005; Cornelissen et al., 2013). So, for example, viewing large numbers of fat bodies would shift the observer's ideal toward a higher BMI (Robinson and Kirkham, 2014; Oldham and Robinson, 2016). Thus, the increased proportion of muscular and lean bodies in the media viewed by our participants may shift their ideal to reflect this change in visual diet. We found significant positive associations between television viewing time, media belief and men's ideal muscularity, suggesting that the media content our participants are watching is to some degree appearance focused: indeed many participants reported watching sports and action movies, genres that would likely contain a high proportion of athletic or muscular male bodies.

An alternative explanation is based not on changes in visual content, but on changes in how different sizes and shapes are valued (visual valency) (Boothroyd et al., 2012). The presentation of muscular, lean bodies as being indicative of high status in the media propagates this as an ideal in Western countries and the spread of Western media across the world disseminates this message into non-WEIRD populations. Furthermore, pre-existing cultural constructions of maleness and masculinity may already incorporate a muscular body type and so men seek out media content that validates and reinforces them. Certainly, participants in this study reported watching mainly action movies, sports content and news programmes - genres that tend to contain a high proportion of stereotypical representations of masculinity, including body types and behaviors.

In addition to media pressure to conform to a lean and muscular ideal, peer and family influences may also shape men's body ideals and contribute to body image concerns (Rodgers et al., 2015). For example, in the United Kingdom it is suggested that the strong drive for muscularity comes from peer pressure and the desire for social status (Swami, 2016). A similar drive for social dominance, fitness and sporting performance is found in adolescent boys and young men in Tonga and Fiji (Ricciardelli et al., 2007a). This suggests a modulating effect of family and peers on the development of body image and body concerns, and the influence of cultural differences between our three groups of men.

Other mechanisms such as social comparison may also be involved in a drive for muscularity (Smolak and Stein, 2006; Karazsia and Crowther, 2009). Social comparison theory (Festinger, 1954) would suggest that exposure to the image of a body (whether in real life or through the media) that is thinner or more muscular than they believe themselves to be would represent an aspirational stimulus which should be the cue for upward social comparison. The larger the difference between what they believe themselves to be and the size and shape of the aspirational stimulus, the stronger the pressure. The presentation of lean muscular bodies in the media as a high status, aspirational ideal might thus induce a drive for muscularity. There is considerable evidence consistent with such a social comparison explanation for the proposed effect of the media on body perception and the drive for muscularity in men in the United Kingdom and the United States (e.g., Smolak and Stein, 2006; Karazsia and Crowther, 2009; Galioto and Crowther, 2013). However, the results from our study are more equivocal. The Ugandan participants had the lowest actual muscularity, which would predict that the difference between the media ideals and their own bodies would be the largest. They should therefore have the strongest drive for muscularity, but this does not seem to be the case.

Study Strengths and Limitations, Future Research

Our research has addressed a critical gap in the body image literature by focusing on men's body image and related body change behaviors in two non-WEIRD populations, Uganda and Nicaragua. The study has several other notable strengths. Firstly, we sampled men of Black African descent in three different settings, sub-Saharan Africa, Central America and the United Kingdom. Secondly, to the best of our knowledge, this is the first study to sample men of Miskitu ethnicity. Finally, we have also taken a more holistic cross-cultural approach, and considered perceptual and attitudinal aspects of men's body image.

The study also has several key strengths relating to the methodologies used to assess the perceptual and attitudinal components of men's body image. We employed well-established, validated self-report questionnaires to measure drive for muscularity, body satisfaction, media belief, and the influence of family and peers. Although these psychometric measures were developed and are predominantly utilized in WEIRD populations, good levels of internal consistency across our sample suggest they were also suitable for use among men in our non-WEIRD contexts. Furthermore, we utilized novel visual stimuli, the Male Adiposity and Muscularity Scale (MAMS), to determine men's perceptions of their current body and their desire for a muscular ideal body. The scale was specifically designed using ethnically non-White male figures to improve ecological validity and enhance participants' ability to identify with the images and thus produce meaningful data. High correlations between men's actual and MAMS perceived body size attest to its construct validity.

While this study has considerable strengths, there were some limitations. Sampling in the two non-WEIRD nations differed somewhat, resulting in a more urbanized Ugandan sample relative to the Nicaraguan sample. Furthermore, we did not include a measure of socioeconomic status (SES) in our analyses, even though evidence suggests that this may be a factor contributing to cross-cultural differences in levels of body dissatisfaction (Swami et al., 2010). We did collect information on participants' income, but these data were rather problematic for several reasons. Firstly, almost 20% of participants were students and reported having very little or no income. Secondly, the incidence of students was not the same across the three country samples. Lastly, we believe that the responses to the income questions may be rather unreliable, at least in the two non-WEIRD samples. It was observed that in these locations some participants were quite reticent about divulging their earnings, while others appeared to exaggerate them in front of the Western researcher. Additionally, it is problematic to simply compare an income total across countries: earning $1,000 in Nicaragua is not the same as earning the equivalent in the United Kingdom: Such a salary would be considered reflective of a high socioeconomic status within Nicaragua, but not in the United Kingdom. We would strongly recommend that future research incorporates a measure that usefully captures socioeconomic status of participants across a variety of cultural contexts. A relatively small sample was recruited in Uganda, compared to the United Kingdom and Nicaraguan groups, resulting in reduced power to detect statistically significant differences between groups. Further, our participants in Uganda all self-identified as Black African (even though tribal affiliation varied considerably), while those in Nicaragua were of several distinct ethnic groups. However, this was anticipated and so ethnicity was included as a variable in our within-participant analyses. Additionally, many of the Black men in our United Kingdom sample reported being born in a range of African countries, and we did not measure acculturation other than the number of years of residence in the United Kingdom. Nevertheless, a majority of this sample had lived in the United Kingdom (or other Western country) for most of their adult lives, and research suggests that living in a Western nation for a number of years is associated with more Western-like body ideals (Tovée et al., 2006). The present study was cross-sectional, meaning we cannot draw causal inferences from our findings. Overall, correlational studies tend to show small effect sizes of media influence on body image, suggesting that media alone may not explain negative body image or related outcomes (Levine and Murnen, 2009). However, experimental evidence shows that exposure to idealized media imagery shifts viewers' own body ideals in the same direction in both WEIRD (Boothroyd et al., 2012) and non-WEIRD samples (Boothroyd et al., 2019), and perceived media pressure precedes body dissatisfaction and unhealthy behavioral outcomes (Barlett et al., 2008). However, thus far there is scant experimental research of this kind carried out with culturally diverse samples outside of Western contexts (Blond, 2008). Future research therefore should include experimental and longitudinal studies in non-WEIRD populations to assess the influence of media beyond shaping body ideals and investigate its role in negative body image and related behavioral outcomes (Holmqvist and Frisén, 2010).

We also acknowledge that media use is changing, especially in the non-WEIRD countries sampled here. However at the time of data collection, TV viewing was the only source of visual imagery for our Nicaraguan participants – very few had smartphones or regular access to the internet. Future research is needed to measure usage of these forms of media and identify their effect on body image among populations in non-WEIRD contexts with the aim of ameliorating negative effects currently witnessed among young people in Western populations (e.g., Fardouly and Vartanian, 2016).

Finally, the limited number of body sizes and shapes presented in the MAMS may have meant that participants selected an "approximate" representation of their body ideals. Future studies would benefit from using methods that allow participants to create "bespoke" bodies in 3D to obtain more accurate representations of their body perceptions (e.g., Crossley et al., 2012; Thornborrow et al., 2018).

CONCLUSION

The present study investigated men's body ideals and body image in two non-WEIRD, non-White populations, Uganda (Africa) and Nicaragua (Central America), and compared them with those of men in the United Kingdom. Overall, men in our non-WEIRD samples displayed less desire for muscularity and less body image concerns than men in our WEIRD sample. Furthermore we have demonstrated that media and peer pressure are associated with men's body image and related body change behaviors in diverse non-White ethnic groups.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The study was granted ethical approval by the University of Lincoln's School of Psychology Research Ethics Committee on the 12th December 2017 (PSY1718346).

AUTHOR CONTRIBUTIONS

All authors were involved throughout the study, wrote the manuscript, and approved the final manuscript. TT, MT, and LB designed and conceived the study. MT and TT created the MAMS visual stimuli. TT, SM, and TO collected the data. TO and TT performed the statistical analyses.

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REFERENCES

Adams, G., Turner, H., and Bucks, R. (2005). The experience of body dissatisfaction in men. *Body Image* 2, 271–283.

Apicella, C. L. (2014). Upper-body strength predicts hunting reputation and reproductive success in Hadza hunter–gatherers. *Evol. Hum. Behav.* 35, 508–518. doi: 10.1016/j.evolhumbehav.2014.07.001

Ayoki, M. (2012). *Uganda's Emerging Middle Class and its Potential Economic Opportunities*. Germany: University Library of Munich.

Bali, R., Sarkar, D., Lantz, B., and Lesmeister, C. (2016). *R: Unleash Machine Learning Techniques*. Birmingham: Packt Publishing Ltd.

Barlett, C. P., Vowels, C. L., and Saucier, D. A. (2008). Meta-analyses of the effects of media images on men's body-image concerns. *J. Soc. Clin. Psychol.* 27, 279–310. doi: 10.1521/jscp.2008.27.3.279

Becker, A. E., Burwell, R. A., Gilman, S. E., Herzog, D. B., and Hamburg, P. (2002). Eating behaviours and attitudes following prolonged exposure to television among ethnic Fijian adolescent girls. *Br. J. Psychiatry* 180, 509–514.

Becker, A. E., Fay, K. E., Agnew-Blais, J., Khan, A. N., Striegel-Moore, R. H., and Gilman, S. E. (2011). Social network media exposure and adolescent eating pathology in Fiji. *Br. J. Psychiatry* 198, 43–50. doi: 10.1192/bjp.bp.110.078675

Blond, A. (2008). Impacts of exposure to images of ideal bodies on male body dissatisfaction: a review. *Body Image* 5, 244–250. doi: 10.1016/j.bodyim.2008.02.003

Boothroyd, L. G., Jucker, J. L., Thornborrow, T., Jamieson, M. A., Burt, D. M., Barton, R. A., et al. (2016). Television exposure predicts body size ideals in rural Nicaragua. *Br. J. Psychol.* 107, 752–767. doi: 10.1111/bjop.12184

Boothroyd, L. G., Jucker, J. L., Thornborrow, T., and Tovée, M. J. (2019). Television consumption drives perceptions of female body attractiveness in a population undergoing technological transition. *J. Pers. Soc. Psychol.* doi: 10.1037/pspi0000224 [Epub ahead of print],

Boothroyd, L. G., Tovée, M. J., and Pollet, T. V. (2012). Visual diet versus associative learning as mechanisms of change in body size preferences. *PLoS One* 7:e48691. doi: 10.1371/journal.pone.0048691

Breiman, L. (2001). Statistical modeling: the two cultures (with comments and a rejoinder by the author). *Stat. Sci.* 16, 199–231.

Campbell, B. C., Pope, H. G., and Filiault, S. (2005). Body image among Ariaal men from northern Kenya. *J. Crosscult. Psychol.* 36, 371–379.

Chang, F. C., Lee, C. M., Chen, P. H., Chiu, C. H., Pan, Y. C., and Huang, T. F. (2013). Association of thin-ideal media exposure, body dissatisfaction and disordered eating behaviors among adolescents in Taiwan. *Eat. Behav.* 14, 382–385. doi: 10.1016/j.eatbeh.2013.05.002

Cheng, H.-L., McDermott, R. C., Wong, Y. J., and La, S. (2016). Drive for muscularity in Asian American men: sociocultural and racial/ethnic factors as correlates. *Psychol. Men Masc.* 17, 215–227. doi: 10.1037/men0000019

Choo, V. (2002). WHO reassesses appropriate body-mass index for Asian populations. *Lancet* 360:235.

Colman, A. M. (2015). *A Dictionary of Psychology: Oxford Quick Reference*. Oxford: Oxford University Press.

Cornelissen, P. L., Johns, A., and Tovée, M. J. (2013). Body size over-estimation in women with anorexia nervosa is not qualitatively different from female controls. *Body Image* 10, 103–111. doi: 10.1016/j.bodyim.2012.09.003

Cramblitt, B., and Pritchard, M. (2013). Media's influence on the drive for muscularity in undergraduates. *Eat. Behav.* 14, 441–446. doi: 10.1016/j.eatbeh.2013.08.003

Crossley, K. L., Cornelissen, P. L., and Tovee, M. J. (2012). What is an attractive body? Using an interactive 3D program to create the ideal body for you and your partner. *PLoS One* 7:e0050601. doi: 10.1371/journal.pone.0050601

Daniel, S., and Bridges, S. K. (2010). The drive for muscularity in men: media influences and objectification theory. *Body Image* 7, 32–38. doi: 10.1016/j.bodyim.2009.08.003

Dogan, O., Bayhan, P., Yukselen, A., and Isitan, S. (2018). Body image in adolescents and its relationship to socio-cultural factors. *Educ. Sci.* 18, 561–577. doi: 10.12738/estp.2018.3.0569

Doris, E., Shekriladze, I., Javakhishvili, N., Jones, R., Treasure, J., and Tchanturia, K. (2015). Is cultural change associated with eating disorders? A systematic review of the literature. *Eat. Weight Disord.* 20, 149–160. doi: 10.1007/s40519-015-0189-9

Edwards, C., Tod, D., and Molnar, G. (2014). A systematic review of the drive for muscularity research area. *Int. Rev. Sport Exerc. Psychol.* 7, 18–41. doi: 10.1080/1750984X.2013.847113

Eisenberg, M. E., Wall, M., and Neumark-Sztainer, D. (2012). Muscle-enhancing behaviors among adolescent girls and boys. *Pediatrics* 130, 1019–1026. doi: 10.1542/peds.2012-0095

Fardouly, J., and Vartanian, L. R. (2016). Social media and body image concerns: Current research and future directions. *Curr. Opin. Psychol.* 9, 1–5.

Festinger, L. (1954). A theory of social comparison processes. *Hum. Relat.* 7, 117–140.

Fiske, L., Fallon, E. A., Blissmer, B., and Redding, C. A. (2014). Prevalence of body dissatisfaction among United States adults: review and recommendations for future research. *Eat. Behav.* 15, 357–365. doi: 10.1016/j.eatbeh.2014.04.010

Forbes, G. B., Jung, J., Vaamonde, J. D., Omar, A., Paris, L., and Formiga, N. S. (2012). Body dissatisfaction and disordered eating in three cultures: Argentina. *Braz. U. S. Sex Roles* 66, 677–694. doi: 10.1007/s11199-011-0105-3

Frederick, D. A., Buchanan, G. M., Sadehgi-Azar, L., Peplau, L. A., Haselton, M. G., Berezovskaya, A., et al. (2007). Desiring the muscular ideal: men's body satisfaction in the United States, Ukraine, and Ghana. *Psychol. Men Masc.* 8, 103–117. doi: 10.1037/1524-9220.8.2.103

Furnham, A., and Baguma, P. (1994). Cross-cultural differences in the evaluation of male and female body shapes. *Int. J. Eat. Disord.* 15, 81–89. doi: 10.1002/1098-108X(199401)15:1<81::AID-EAT2260150110>3.0.CO;2-D

Galioto, R., and Crowther, J. H. (2013). The effects of exposure to slender and muscular images on male body dissatisfaction. *Body Image* 10, 566–573. doi: 10.1016/j.bodyim.2013.07.009

Girard, M., Chabrol, H., and Rodgers, R. F. (2017). Support for a modified tripartite dual pathway model of body image concerns and risky body change behaviors in French young men. *Sex Roles* 78, 799–809. doi: 10.1007/s11199-017-0850-z

Góngora, V. C., Licea, V. C., Chams, M. R. M., and Thornborrow, T. (2020). Assessing the measurement invariance of a Latin-American Spanish translation of the body appreciation scale-2 in Mexican, Argentinean, and Colombian adolescents. *Body Image* 32, 180–189. doi: 10.1016/j.bodyim.2020.01.004

Grabe, S., Ward, L. M., and Hyde, J. S. (2008). The role of the media in body image concerns among women: a meta-analysis of experimental and correlational studies. *Psychol. Bull.* 134, 460–476. doi: 10.1037/0033-2909.134.3.460

Gray, P. B., and Frederick, D. A. (2012). Body image and body type preferences in St. Kitts, Caribbean: a cross-cultural comparison with U.S. samples regarding attitudes towards muscularity, body fat, and breast size. *Evol. Psychol.* 10, 631–655. doi: 10.1177/147470491201000319

Harrison, K. (2003). Television viewers' ideal body proportions: the case of the curvaceously thin woman. *Sex Roles* 48, 255–264.

Hausenblas, H. A., Campbell, A., Menzel, J. E., Doughty, J., Levine, M., and Thompson, J. K. (2013). Media effects of experimental presentation of the ideal physique on eating disorder symptoms: a meta-analysis of laboratory studies. *Clin. Psychol. Rev.* 33, 168–181. doi: 10.1016/j.cpr.2012.10.011

Henrich, J., Heine, S. J., and Norenzayan, A. (2010). Beyond WEIRD: towards a broad-based behavioral science. *Behav. Brain Sci.* 33, 111–135. doi: 10.1017/S0140525X10000725

Holmqvist, K., and Frisén, A. (2010). Body dissatisfaction across cultures: findings and research problems. *Eur. Eat. Disord. Rev.* 18, 133–146. doi: 10.1002/erv.965

James, G., Witten, D., Hastie, T., and Tibshirani, R. (2013). *An Introduction to Statistical Learning*, Vol. 112. New York: Springer, 18.

Jucker, J. L., Thornborrow, T., Beierholm, U., Burt, D. M., Barton, R. A., Evans, E. H., et al. (2017). Nutritional status and the influence of TV consumption on female body size ideals in populations recently exposed to the media. *Sci. Rep.* 7:8438. doi: 10.1038/s41598-017-08653-z

Jung, J., Forbes, G. B., and Chan, P. (2010). Global body and muscle satisfaction among college men in the United States and Hong Kong-China. *Sex Roles* 63, 104–117. doi: 10.1007/s11199-010-9760-z

Karazsia, B. T., and Crowther, J. H. (2009). Social body comparison and internalization: mediators of social influences on men's muscularity-oriented body dissatisfaction. *Body Image* 6, 105–112. doi: 10.1016/j.bodyim.2008.12.003

Karazsia, B. T., Murnen, S. K., and Tylka, T. L. (2017). Is body dissatisfaction changing across time? A cross-temporal meta-analysis. *Psychol. Bull.* 143:293. doi: 10.1037/bul0000081

Kelly, N. R., Cotter, E. W., Tanofsky-Kraff, M., and Mazzeo, S. E. (2015). Racial variations in binge eating, body image concerns, and compulsive exercise among men. *Psychol. Men Masc.* 16:326.

Kesavachandran, C. N., Bihari, V., and Mathur, N. (2012). The normal range of body mass index with high body fat percentage among male residents of Lucknow city in north India. *Indian J. Med. Res.* 135:72.

Lavender, J. M., Brown, T. A., and Murray, S. B. (2017). Men, muscles, and eating disorders: an overview of traditional and muscularity-oriented disordered eating. *Curr. Psychiatry Rep.* 19:32.

Lear, S. A., James, P. T., Ko, G. T., and Kumanyika, S. (2010). Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. *Eur. J. Clin. Nutr.* 64, 42–46. doi: 10.1038/ejcn.2009.70

Levine, M. P., and Murnen, S. K. (2009). "Everybody knows that mass media are/are not [pick one] a cause of eating disorders": a critical review of evidence for a causal link between media, negative body image, and disordered eating in females. *J. Soc. Clin. Psychol.* 28, 9–42.

Markey, C. N. (2004). Culture and the development of eating disorders: a tripartite model. *Eat. Disord.* 12, 139–156.

Maruf, F., Akinpelu, A., and Nwankwo, M. (2012). Perceived body image and weight: discrepancies and gender differences among University undergraduates. *Afr. Health Sci.* 12, 464–472.

McCabe, M. P., Busija, L., Fuller-Tyszkiewicz, M., Ricciardelli, L., Mellor, D., and Mussap, A. (2015). Sociocultural influences on strategies to lose weight, gain weight, and increase muscles among ten cultural groups. *Body Image* 12, 108–114. doi: 10.1016/j.bodyim.2014.10.008

McCabe, M. P., and Ricciardelli, L. A. (2004). Body image dissatisfaction among males across the lifespan: a review of past literature. *J. Psychosom. Res.* 56, 675–685. doi: 10.1016/S0022-3999(03)00129-6

McCreary, D. R., and Sasse, D. K. (2000). An exploration of the drive for muscularity in adolescent boys and girls. *J. Am. College Health* 48, 297–304.

Meehan, O. L., and Katzman, M. A. (2001). "Argentina: the social body at risk," in *Eating Disorders and Cultures in Transition*, eds M. Nasser, M. A. Katzman, and R. A. Gordon (London: Brunner-Routledge), 148–162.

Mellor, D., McCabe, M., Ricciardelli, L., and Merino, M. E. (2008). Body dissatisfaction and body change behaviors in Chile: the role of sociocultural factors. *Body Image* 5, 205–215. doi: 10.1016/j.bodyim.2008.01.004

Miller, W. C., Lindeman, A. K., Wallace, J., and Niederpruem, M. (1990). Diet composition, energy intake, and exercise in relation to body fat in men and women. *Am. J. Clin. Nutr.* 52, 426–430.

Morrison, T. G., Morrison, M. A., and Hopkins, C. (2003). Striving for bodily perfection? An exploration of the drive for muscularity in Canadian men. *Psychol. Men Masc.* 4:111.

Murray, S. B., Griffiths, S., and Mond, J. M. (2016). Evolving eating disorder psychopathology: conceptualising muscularity-oriented disordered eating. *Br. J. Psychiatry* 208, 414–415. doi: 10.1192/bjp.bp.115.168427

Nelson, L. H., and Tucker, L. A. (1996). Diet composition related to body fat in a multivariate study of 203 men. *J. Am. Diet. Assoc.* 96, 771–777.

Nouri, M., Hill, L. G., and Orrell-Valente, J. K. (2011). Media exposure, internalization of the thin ideal, and body dissatisfaction: comparing Asian American and European American college females. *Body Image* 8, 366–372. doi: 10.1016/j.bodyim.2011.05.008

Okoro, E. O., Oyejola, B. A., Etebu, E. N., Sholagberu, H., Kolo, P. M., Chijioke, A., et al. (2014). Body size preference among Yoruba in three Nigerian communities. *Eat. Weight Disord.* 19, 77–88. doi: 10.1007/s40519-013-0060-9

Oldham, M., and Robinson, E. (2016). Visual weight status misperceptions of men: Why overweight can look like a healthy weight. *J. Health Psychol.* 21, 1768–1777. doi: 10.1177/1359105314566257

Pritchard, M., and Cramblitt, B. (2014). Media influence on drive for thinness and drive for muscularity. *Sex Roles* 71, 208–218. doi: 10.1007/s11199-014-0397-1

R Studio Team (2016). *RStudio: Integrated Development for R*. Boston, MA: RStudio, Inc.

Ricciardelli, L. A., McCabe, M. P., and Banfield, S. (2000). Body image and body change methods in adolescent boys: role of parents, friends and the media. *J. Psychosom. Res.* 49, 189–197.

Ricciardelli, L. A., McCabe, M. P., Mavoa, H., Fotu, K., Goundar, R., Schultz, J., et al. (2007a). The pursuit of muscularity among adolescent boys in Fiji and Tonga. *Body Image* 4, 361–371. doi: 10.1016/j.bodyim.2007.07.001

Ricciardelli, L. A., McCabe, M. P., Williams, R. J., and Thompson, J. K. (2007b). The role of ethnicity and culture in body image and disordered eating among males. *Clin. Psychol. Rev.* 27, 582–606. doi: 10.1016/j.cpr.2007.01.016

Robinson, E., and Kirkham, T. C. (2014). Is he a healthy weight? Exposure to obesity changes perception of the weight status of others. *Int. J. Obes.* 38, 663–667. doi: 10.1038/ijo.2013.154

Rodgers, R. F., Berry, R., and Franko, D. L. (2018). Eating disorders in ethnic minorities: an update. *Curr. Psychiatry Rep.* 20:90. doi: 10.1007/s11920-018-0938-3

Rodgers, R. F., McLean, S. A., and Paxton, S. J. (2015). Longitudinal relationships among internalization of the media ideal, peer social comparison, and body dissatisfaction: implications for the tripartite influence model. *Dev. Psychol.* 51, 706–713. doi: 10.1037/dev0000013

Rodgers, R. F., Watts, A. W., Austin, S. B., Haines, J., and Neumark-Sztainer, D. (2017). Disordered eating in ethnic minority adolescents with overweight. *Int. J. Eat. Disord.* 50, 665–671.

Rohde, P., Stice, E., and Gau, J. M. (2017). Predicting persistence of eating disorder compensatory weight control behaviors. *Int. J. Eat. Disord.* 50, 561–568. doi: 10.1002/eat.22639

Rokach, L., and Maimon, O. (2015). Data mining with decision trees–theory and applications 2nd Edition. *Series Mach. Percept. Artif. Intell.* 81:328.

Sánchez-Carracedo, D., Barrada, J. R., López-Guimerà, G., Fauquet, J., Almenara, C. A., and Trepat, E. (2012). Analysis of the factor structure of the sociocultural attitudes towards appearance questionnaire (SATAQ-3) in Spanish secondary-school students through exploratory structural equation modeling. *Body Image* 9, 163–171. doi: 10.1016/j.bodyim.2011.10.002

Sepulveda, A. R., Parks, M., Blanco, M., de Pellegrini, Y., Anastasiadou, D., and Bustos, C. (2015). A confirmatory factor analysis of the Spanish version of the drive for muscularity scale (DMS) in adolescent males. *Body Image* 14, 13–19. doi: 10.1016/j.eatbeh.2016.01.010

Shiwaku, K., Anuurad, E., Enkhmaa, B., Kitajima, K., and Yamane, Y. (2004). Appropriate BMI for Asian populations. *Lancet* 363:1077.

Smirles, K. E., and Lin, L. (2018). Changes in anti-fat weight bias in women after exposure to thin and plus-sized models. *Soc. Sci. J.* 55, 193–197.

Smolak, L., and Stein, J. A. (2006). The relationship of drive for muscularity to sociocultural factors, self-esteem, physical attributes gender role, and social comparison in middle school boys. *Body Image* 3, 121–129.

Stratton, R., Donovan, C., Bramwell, S., and Loxton, N. J. (2015). Don't stop till you get enough: factors driving men towards muscularity. *Body Image* 15, 72–80. doi: 10.1016/j.bodyim.2015.07.002

Swami, V. (2016). Masculinities and ethnicities: ethnic differences in drive for muscularity in British men and the negotiation of masculinity hierarchies. *Br. J. Psychol.* 107, 577–592. doi: 10.1111/bjop.12162

Swami, V., Frederick, D. A., Aavik, T., Alcalay, L., Allik, J., Anderson, D., et al. (2010). The attractive female body weight and female body dissatisfaction in 26 countries across 10 world regions: Results of the International Body Project I. *Pers. Soc. Psychol. Bull.* 36, 309–325. doi: 10.1177/0146167209359702

Tamplin, N. C., McLean, S. A., and Paxton, S. J. (2018). Social media literacy protects against the negative impact of exposure to appearance ideal social media images in young adult women but not men. *Body Image* 26, 29–37. doi: 10.1016/j.bodyim.2018.05.003

Thompson, J. K., and Heinberg, L. J. (1999). The media's influence on body image disturbance and eating disorders: We've reviled them, now can we rehabilitate them? *J. Soc. Issues* 55, 339–353.

Thompson, J. K., Heinberg, L. J., Altabe, M., and Tantleff-Dunn, S. (1999). *Exacting Beauty: Theory, Assessment, and Treatment of Body Image Disturbance*. Washington, DC: American Psychological Association.

Thompson, J. K., Van Den Berg, P., Roehrig, M., Guarda, A. S., and Heinberg, L. J. (2004). The sociocultural attitudes towards appearance scale-3 (SATAQ-3): Development and validation. *Int. J. Eat. Disord.* 35, 293–304. doi: 10.1002/eat.10257

Thornborrow, T., Jucker, J. L., Boothroyd, L. G., and Tovée, M. J. (2018). Investigating the link between television viewing and men's preferences for female body size and shape in rural Nicaragua. *Evol. Hum. Behav.* 39, 538–546.

Thornhill, R., and Grammer, K. (1999). The body and face of woman: One ornament that signals quality? *Evol. Hum. Behav.* 20, 105–120.

Tiggemann, M. (2015). Considerations of positive body image across various social identities and special populations. *Body Image* 14, 168–176. doi: 10.1016/j.bodyim.2015.03.002

Tovée, M. J., Swami, V., Furnham, A., and Mangalparsad, R. (2006). Changing perceptions of attractiveness as observers are exposed to a different culture. *Evol. Hum. Behav.* 27, 443–456.

Tylka, T. L. (2011). Refinement of the tripartite influence model for men: dual body image pathways to body change behaviors. *Body Image* 8, 199–207. doi: 10.1016/j.bodyim.2011.04.008

Tylka, T. L., and Wood-Barcalow, N. L. (2015). The Body Appreciation Scale-2: item refinement and psychometric evaluation. *Body Image* 12, 53–67. doi: 10.1016/j.bodyim.2014.09.006

Ugandan Bureau of Statistics (2019). Available online at: https://www.ubos.org/explore-statistics/statistical-datasets/220/. (accessed November 23, 2019).

Verheggen, R. J. H. M., Maessen, M. F. H., Green, D. J., Hermus, A. R. M. M., Hopman, M. T. E., and Thijssen, D. H. T. (2016). A systematic review and meta−analysis on the effects of exercise training versus hypocaloric diet: distinct effects on body weight and visceral adipose tissue. *Obes. Rev.* 17, 664–690. doi: 10.1111/obr.12406

Waling, A. (2017). "We are so pumped full of shit by the media":masculinity, magazines, and the lack of self-identification. *Men Masc.* 20, 427–452. doi: 10.1177/1097184x16652654

Wells, J. C. K., Cole, T. J., Bruner, D., and Treleaven, P. (2008). Body shape in American and British adults: between-country and inter-ethnic comparisons. *Int. J. Obes.* 32, 152.

Wells, J. C. K., Treleaven, P., and Charoensiriwath, S. (2012). Body shape by 3-D photonic scanning in Thai and UK adults: comparison of national sizing surveys. *Int. J. Obes.* 36:148. doi: 10.1038/ijo.2011.51

Wildes, J. E., Emery, R. E., and Simons, A. D. (2001). The roles of ethnicity and culture in the development of eating disturbance and body dissatisfaction: a meta-analytic review. *Clin. Psychol. Rev.* 21, 521–551.

Wildman, R. P., Gu, D., Reynolds, K., Duan, X., and He, J. (2004). Appropriate body mass index and waist circumference cutoffs for categorization of overweight and central adiposity among Chinese adults. *Am. J. Clin. Nutr.* 80, 1129–1136.

Winkler, C., and Rhodes, G. (2005). Perceptual adaptation affects attractiveness of female bodies. *Br. J. Psychol.* 96, 141–154. doi: 10.1348/000712605X36343

World Factbook (2019). *Central Intelligence Agency Website*. Available online at: https://www.cia.gov/library/publications/the-world-factbook/

Xu, X., Mellor, D., Kiehne, M., Ricciardelli, L. A., McCabe, M. P., and Xu, Y. (2010). Body dissatisfaction, engagement in body change behaviors and sociocultural influences on body image among Chinese adolescents. *Body Image* 7, 156–164. doi: 10.1016/j.bodyim.2009.11.003

Yanover, T., and Thompson, J. K. (2010). Perceptions of health and attractiveness: the effects of body fat, muscularity, gender, and ethnicity. *J. Health Psychol.* 15, 1039–1048. doi: 10.1177/1359105309360426

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Motion and Gender-Typing Features Interact in the Perception of Human Bodies

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The human body conveys socially relevant information, including a person's gender. Several studies have shown that both shape and motion inform gender judgments of bodies. However, while body shape seems to influence more the judgment of female bodies, body motion seems to play a major role in the judgments of male bodies. Yet, the interdependence of morphologic and dynamic cues in shaping gender judgment and attractiveness evaluation in body perception is still unclear. In two experiments, we investigated how variations of implied motion and shape interact in perceptual and affective judgments of female and male bodies. In Experiment 1, participants were asked to provide ratings for masculinity and femininity of virtual renderings of human bodies with variable gender-typing features and implied motion. We found evidence of a tendency to perceive bodies in static poses as more feminine and bodies in dynamic poses as more masculine. In Experiment 2, participants rated the same pictures for dynamism and pleasantness. We found that male bodies were judged more dynamic than female bodies with the same pose. Also, female bodies were liked more in static than in dynamic poses. A mediation analysis allowed us to further shed light on the relationship between gender-typing features and motion, suggesting that the less is the movement conveyed by a female body, the greater is an observer's sensitivity to its femininity, and this leads to a more positive evaluation of its pleasantness. Our findings hint to an association between stillness and femininity in body perception, which can stem from either the evolutionary meaning of sexual selection and/or the influence of cultural norms.

Keywords: body image, sex categorization, gender perception, gender bias, attractiveness, body aesthetic, implied motion

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INTRODUCTION

Gender is one of the most significant constructs in human social organization. Humans can rapidly differentiate between male and female conspecifics, relying on a heightened sensitivity to the biological commonalities that make an individual a male or a female. The evolution of this ability has been likely driven by the reproductive necessity to recognize the natural features of a potential mate. Even when primary sex characteristics are not visible, other morphological features of the body can easily mark sexual dimorphism. Among these features, the waist-to-hip ratio (WHR), which is the circumference of the waist relative to the hips, is considered an important body cue to accurately discriminate men from women (Lippa, 1983; Johnson, 2004; Johnson et al., 2012). Indeed, after puberty, women accumulate more fat on the hips than men and, over the years, the similarity in WHR between boys and girls decreases (Singh, 1993). Another sexually dimorphic feature is the shoulder-to-hip ratio (SHR), which is the circumference of the shoulders relative to the hips, which tends to be higher in men than in women (Hugill et al., 2011). Accordingly, eye-tracking studies have shown that, while men spend more time examining the waist area of women's bodies, women focus their attention on the upper body of men (Dixson et al., 2011, 2014), suggesting that the use of WHR and SHR might be more important for evaluating female and male bodies, respectively.

However, not only the morphological appearance of the body, but also its dynamicity may inform about gender, particularly when morphological features provide ambiguous information, such as when people are seen heavily dressed and/or from a considerable physical distance (Johnson and Tassinary, 2005). Since men and women move differently, gender judgment is tightly linked to body movement perception (Kozlowski and Cutting, 1977; Mather and Murdoch, 1994; Kerrigan et al., 1998). Accordingly, people can accurately detect gender from mere point-light displays of walking figures (Kozlowski and Cutting, 1977; Mather and Murdoch, 1994). Indeed, while walking with more hip translations (sway) is judged as more feminine, walking with more shoulder translations (swagger) is judged as more masculine. Further, McDonnell et al. (2007) have demonstrated that motion *per se* can guide gender judgment when morphological cues are ambiguous, for example, in case of androgynous bodies. In fact, when typical feminine or masculine walking kinematics is applied to a neutral body figure, gender judgment follows the applied walking kinematics (McDonnell et al., 2007). Thus, there is evidence that people consider both morphologic and dynamic cues as reliable information on which they build their gender judgments.

Interestingly, the compatibility between morphological and dynamic cues of gender categorization leads to greater aesthetic appreciation of a body, with swaying female bodies and swaggering male bodies being judged more attractive (Johnson and Tassinary, 2007). From an evolutionary perspective, body attractiveness plays a key role in sexual selection, as it is the main vehicle to appeal a partner and prompt reproductive behavior. However, since the factors regulating health and reproductive capabilities cannot be directly observed, sexual selection may have favored psychological adaptations to attend to bodily features that are correlated with a greater procreative value (Symons and Buss, 1994; Sugiyama, 2004). Within this framework, studies have shown that different bodily features signal procreative value in men and women. For example, a man can increase his reproductive success by choosing a woman who is highly fecund, thus attending more to morphological body features (e.g., WHR) that signal female fertility. Indeed, WHR has been documented as a strong indicator of female fertility (Singh, 1993) as well as a reliable measure in the judgment of women's body attractiveness (Grammer et al., 2003; Singh and Singh, 2011) in a consistent way across many populations in men's preferences (Dixon et al., 2007; Sorokowski and Sorokowska, 2012; Brooks et al., 2015). Conversely, women may be more prone to choose a male mate with greater competitive drive (Archer, 2009) in order to provide resources to raise her offspring. This is consistent with data showing that women rate as more attractive taller and more muscular men (Mautz et al., 2013) and that body composition in men is not related to sperm motility, an indicator of male fertility (Fejes et al., 2005), but rather with physical strength (Windhager et al., 2011). Further, women seem to infer the health and strength quality of a man via active displays of the body, such as in dance (Hugill et al., 2009, 2010; Neave et al., 2011), which can be viewed as an important part of male courtship (Sheets-Johnstone, 2005). This is in keeping with the special role of body movements in communicating men's formidability (i.e., fighting ability and resource-holding potential).

The pressure of sexual selection on different survival values of men and women has blended into stereotypical expectations about gender-specific features that men and women are encouraged to exhibit in given socio-cultural contexts. Indeed, society not only shapes personality and behavior, but also the way in which the body appears (Nicholson, 1994). Applying undeniable societal pressure toward a thin-ideal shape for girls (Blaivas et al., 2002; Hawkins et al., 2004; Grabe et al., 2008) and an increased muscular body for boys (Hawkins et al., 2004; Daniel and Bridges, 2010), mass media reinforce the embodiment of gender-role norms. For example, it has been documented that men use physical activity to showcase their masculinity, since it helps to emphasize muscularity and, consequently, to be identified as a stronger individual (Drummond, 2008). Thus, although within the last decades women have challenged the myth that sport is a prerogative of men, the overrepresentation of male athletes in the media compared to female athletes is still persistent, with over 94% of coverage being dedicated to men (Cooky et al., 2015; Hovden and von der Lippe, 2019). Furthermore, the sports achievements of male athletes are regarded as more important than those of female athletes, who are rather mentioned for their physical attractiveness. In this sense, while morphological cues are emphasized for the judgment of women (Tolman et al., 2006), masculine gender-typing features are more related to performance and activities, including personal attributes like being a powerful, strong, and efficacious individual (Mishkind et al., 1986; McCreary et al., 2005).

In sum, both evolutionist and socio-cultural studies have provided numerous clues about the association between specific forms and movements of a body and the perception of its femininity/masculinity. Furthermore, these studies have also shown that morphological and dynamic cues may differently influence the aesthetic appreciation of a male or female body. What is unclear, however, is whether and how form and movement cues may influence each other. A previous study (Cazzato et al., 2012) showed not only that thinner and more dynamic bodies received more positive aesthetic appreciation, but also that the perception of the size of a body was influenced by its dynamicity, with the same body being judged thinner when displayed in a dynamic than in a static posture. Here, we investigated how variations of gender-typing morphological features (e.g., WHR) and dynamicity (static vs. moving posture) influence each other in guiding gender judgment and aesthetic appreciation of a body. To this aim, we created a pool of images of 3-D rendered bodies differing for the multivariate embodiment of sex-specific morphological features and for implied movement. In two experiments, participants were asked to rate them for femininity and masculinity (Experiment 1) and for dynamism and attractiveness (Experiment 2). We predicted that static and dynamic body postures should differently influence the perception of the gender-typing features of male and female bodies. In particular, we expected that static poses applied to a morphologically female figure would increase the perception of its femininity as well as the appreciation of its aesthetic value; conversely, dynamic poses would lead to the same pattern of effects in the case of a morphologically male figure.

EXPERIMENT 1

Materials and Methods

Participants

A sample of 30 students (17 female) from the University of Udine (Italy) took part in the experiment in return for course credits. They were aged 18–35 years (mean = 26.63, *SD* = 5.15) and reported normal or corrected-to-normal visual acuity in both eyes. No participants reported any current neurological or psychiatric disorders. Written informed consent was obtained from each participant. The study procedures were approved by the institutional ethics review board (Commissione di Garanzia per il rispetto dei principi etici nell'attività di ricerca sugli esseri umani, Department of Language and Literature, Communication, Education and Society, University of Udine, Italy; Study Protocol CGPER-2019-12-09-02) and were in accordance with the ethical standards of the 1964 Declaration of Helsinki. Participants were naive to the aims and hypothesis of the experiment and a study debriefing was conducted at the end of the experiment. All participants were right-handed as ascertained with standard handedness inventory (Oldfield, 1971).

Stimuli

To systematically control for the masculinity/femininity traits and implied motion of our body stimuli, we used the software Character Creator 3.0 (Reallusion, San Francisco, CA, United States). Four virtual-human models (two female and two male models) were previously selected from the default database. By using the software function to manipulate the percentage of masculinity/femininity traits embodied by a neutral body, we produced two different versions of each model setting the amount of gender typicality traits at 60 or 90%. This allowed us to obtain more or less masculine/feminine bodies for each identity. Moreover, each body was rendered in 10 different daily poses, namely, five static (e.g., standing, open, idle, and turned postures) and five moving poses (e.g., running, walking, jumping, dancing, moving), selected from the default folders of static and dynamic poses available in Character Creator (see **Figure 1**). Bodies could be viewed from a frontal or three-quarter view and were pictured against a black background. Thus, in total, we had two female and two male models depicted in two different versions (60 or 90% gender typicality) and rendered in 10 different postures for a total of 80 different body images. Furthermore, pictures were imported into GIMP 2.10.8 (GNU Image Manipulation Program, Berkeley, CA, United States) in order to produce a mirrored version of each image and thus obtain a pool of 160 different body stimuli. Importantly, for all images, the head, pectoral, and pelvic areas were blurred in order to mask primary sexual characteristics, keeping, however, enough morphological information to visually convey the sexual phenotype (see **Figure 1**).

Procedure

The experiment was created with E-Prime software (version 2.0, Psychology Software Tools, Inc., Pittsburgh, PA, United States). During the experimental session, participants sat 60 cm away from a 19-in PC monitor (resolution: 1,360 $\times$ 768 pixels; refresh frequency: 60 Hz), on which 600 $\times$ 600 pixel images were presented one at a time at the center of the screen. In different blocks, participants were asked to provide two different judgments about the bodies, namely, either a femininity judgment ("How much do you think this body is feminine?"; in Italian, "*Quanto ritieni che questo corpo sia femminile?*") or a masculinity judgment ("How much do you think this body is masculine?"; in Italian, "*Quanto ritieni che questo corpo sia maschile?*"). Each trial started with the appearance of the body image with a 1–7 Likert-scale below, which remained on the screen until response. Participants rated the two attributes for each body by using 1 (not at all) to 7 (very much) keyboard keys with both hands. Soon after participants' response, the image disappeared and the next trial was presented. The same stimuli were randomly presented once in the Femininity block and once in the Masculinity block. The order of presentation of each block was counterbalanced across participants.

Data Handling

All the analyses were performed using ANOVA designs implemented in STATISTICA software (Stat Soft, version 10, StatSoft Inc., Tulsa, OK, United States). For each experimental block (i.e., Femininity and Masculinity), individual rating values were collected and separately submitted to three-way ANOVA with Posture (static vs. dynamic poses), Gender (male vs. female stimuli), and Typicality (60% vs. 90% gender traits) as within-subject variables and Gender group (male vs. female observers) as a between-subjects variable. Significant interactions were explored with the Tukey *post-hoc* test to correct for multiple comparisons. Significance threshold was set at $p < 0.05$. Effect size was estimated with partial eta squared (η_p^2). Judgment values are shown as mean $\pm$ standard error (SE).

Results

Femininity Judgments

The ANOVA on femininity judgments (**Figure 2A**) showed, as expected, significant main effects of Gender [$F_{(1,29)} = 326.98$; $p < 0.001$; $\eta_p^2 = 0.919$] and Typicality [$F_{(1,29)} = 5.68$; $p = 0.024$; $\eta_p^2 = 0.164$], which were further qualified by a significant Gender $\times$ Typicality interaction [$F_{(1,29)} = 134.17$; $p < 0.001$; $\eta_p^2 = 0.822$]. Tukey *post-hoc* tests [mean square

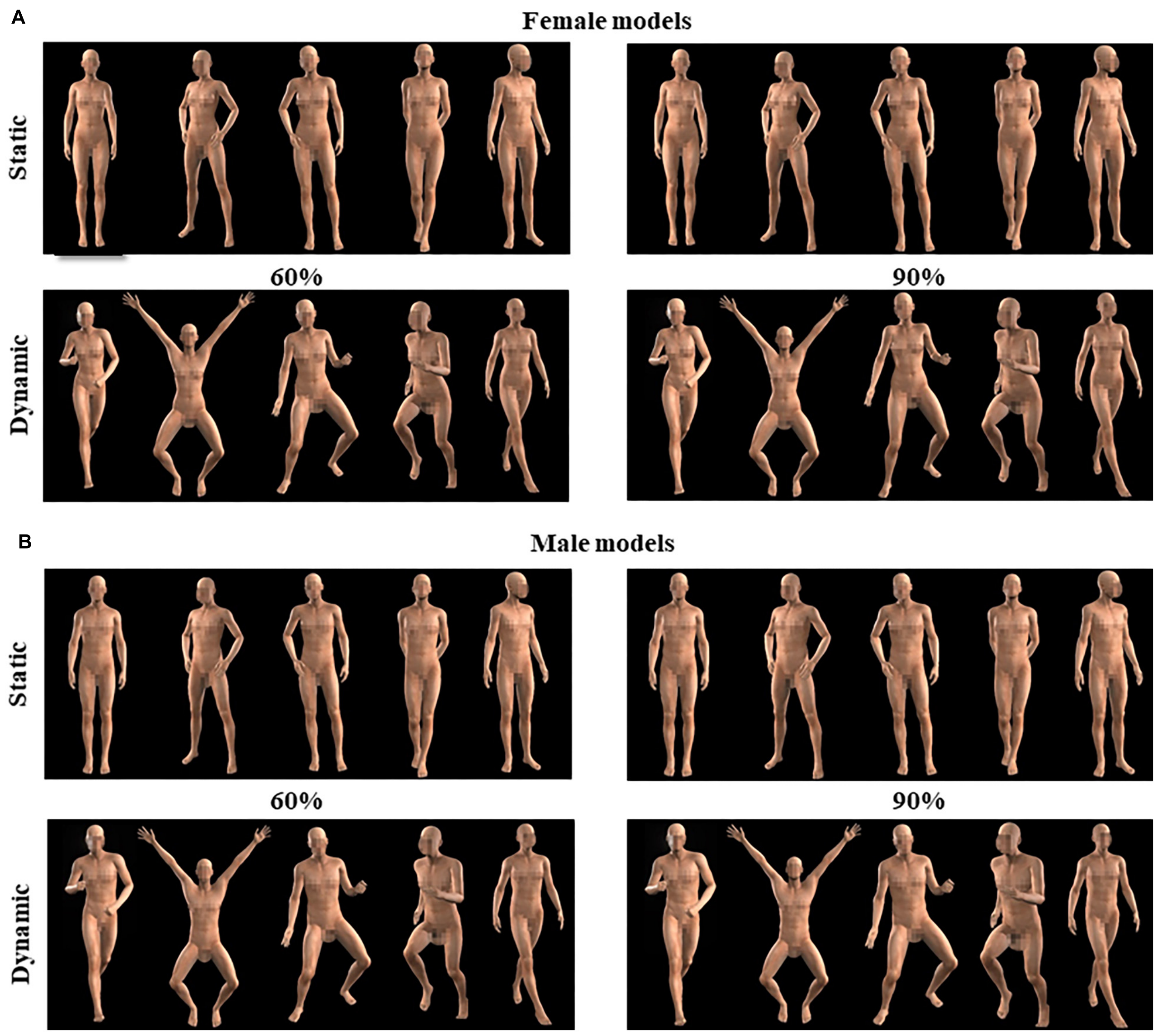

FIGURE 1 | Examples of female and male virtual models used in the study. The examples depict the body sex-typing variation of either static or dynamic female **(A)** and male **(B)** models.

error (MSE) = 0.06525, *df* = 29] showed that femininity judgments continuously increased from the 90% male stimuli, which were judged as the least feminine bodies, to the 90% female stimuli, which were judged as the most feminine bodies (all *ps* < 0.001). Importantly, however, we also found a main effect of Posture [$F_{(1,29)} = 10.67$; $p = 0.003$; $\eta_p^2 = 0.2690$], showing higher level of femininity for static than dynamic poses. Finally, the Posture × Gender × Typicality interaction [$F_{(1,29)} = 4.587$; $p = 0.04$; $\eta_p^2 = 0.1365$] was also significant, showing that the effect of posture was different for body figures with different feminine/masculine typicality. Tukey *post-hoc* comparisons (MSE = 0.02869; *df* = 29) revealed that both 60% ($p = 0.017$) and 90% ($p = 0.019$) male stimuli received higher femininity judgments when displayed in static than dynamic poses. The same effect of posture, however, was only obtained for the 60% ($p < 0.001$), but not the 90% ($p = 0.525$) female stimuli. Furthermore, femininity judgments increased with higher feminine typicality and with lower masculine typicality, independently from postures (all *ps* < 0.001). However, the 60% static female stimuli received comparable feminine judgments than the 90% dynamic ones ($p = 0.289$), suggesting that a static posture increased the feminine judgments of a low-typical body up to the level of a dynamic typical female body (or that a dynamic posture reduced the feminine judgments of a typical female body to the level of a static low-typical body). No significant main effect or interaction of Gender group was obtained but a Gender group × Gender interaction [$F_{(1,28)} = 6.053$; $p = 0.02$; $\eta_p^2 = 0.1777$], which showed that

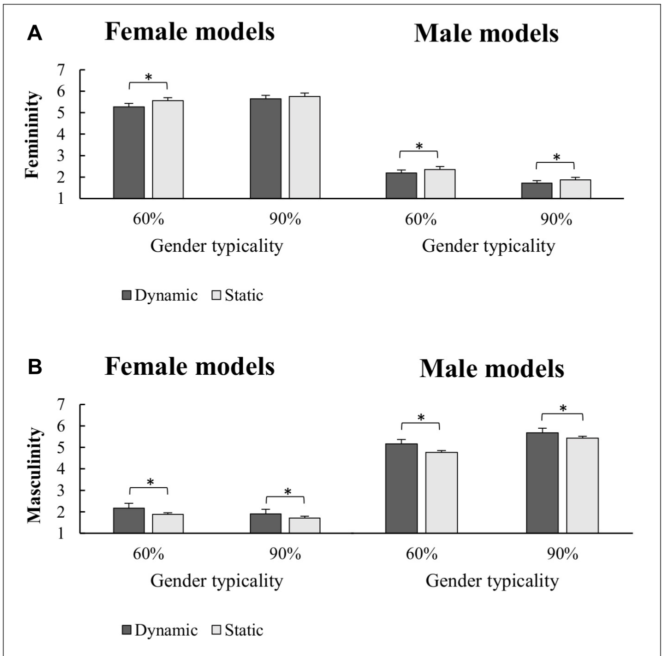

FIGURE 2 | Mean and standard error of mean for Femininity **(A)** and Masculinity **(B)** judgments of Female and Male models as a function of implied motion (static/dynamic) along the two categories of sex-typing traits expressed (60%/90%). Asteriks indicate significant pairwise comparisons.

the difference between female and male models tended to be higher for female than male participants; however, *post-hoc* test did not reveal any significant between-group difference (all *p*s > 0.27).

Masculinity Judgments

The ANOVA on masculinity judgments (**Figure 2B**) showed significant main effects of Gender [$F_{(1,29)}$ = 303.36; p < 0.001; η^2_p = 0.913] and Typicality [$F_{(1,29)}$ = 26.338; p < 0.001; η^2_p = 0.476] as well as a significant two-way Gender × Typicality interaction [$F_{(1,29)}$ = 171.994; p < 0.001; η^2_p = 0.856]. Tukey *post-hoc* tests [MSE = 0.0592, *df* = 29] showed a specular pattern of results as compared to femininity judgments, with continuously increasing masculinity judgments from the 90% female stimuli, which were judged as the least masculine bodies, to the 90% male stimuli, which were judged as the most masculine bodies (all *p*s < 0.001). Again, we found a main effect of Posture [$F_{(1,29)}$ = 32.85; p < 0.001; η^2_p = 0.531], which revealed higher judgments of masculinity for dynamic than static poses and was qualified by a significant Posture × Typicality interaction [$F_{(1,29)}$ = 8.74; p = 0.006; η^2_p = 0.232]. Tukey *post-hoc* tests [MSE = 0.02808, *df* = 29] showed that dynamic poses led to higher masculine judgments independently from gender typicality, even if the effect of posture was higher for the 60% (dynamic vs. static pose difference, 0.694 ± 0.115) than for the 90% (dynamic vs. static pose difference, 0.439 ± 0.1) bodies [planned comparison, $F_{(1,29)}$ = 8.74, p = 0.006]. No significant main effect or interaction of Gender group was obtained (all F < 2.928, *p*s > 0.1).

Discussion

The results of Experiment 1 showed that implied motion modulated the perception of feminine gender-typing morphological features, since the same low-typical bodies received lower feminine and higher masculine judgments when displayed in dynamic than in static poses. This points to an association between stillness and femininity. Importantly, the effects of implied motion on femininity and masculinity judgments were comparable for male and female observers, since the effect of posture was not modulated by gender group. From this pattern of results, however, it is not possible to discern whether gender-typing feminine forms may also modulate the perception of implied motion conveyed by a static picture of a body. Furthermore, it is also unclear whether the compatibility between two seemingly associated body cues, namely, stillness and femininity, also affects body aesthetic appreciation, as shown for gender-typing bodies moving in a gender-typical way (Johnson and Tassinary, 2007). To address these issues, we implemented a second experiment testing a subset of participants who took part to Experiment 1 and agreed to complete a second session.

EXPERIMENT 2

Materials and Methods

The same stimuli, procedure, and data handling approach as in Experiment 1 were used, but participants (N = 21, 11 women) aged 19–34 years (mean = 26.75, *SD* = 4.82) were asked to judge, in separate blocks, the dynamism ("How much do you think this body is dynamic?"; in Italian, "*Quanto ritieni che questo corpo sia dinamico?*") or the pleasantness ("How much do you like this body?"; in Italian, "*Quanto ti piace questo corpo?*") of the stimuli. The order of block presentation was balanced across participants. The same repeated-measure variables (Posture × Gender × Typicality) as in Experiment 1 were tested, but the Gender group was not tested since it did not modulate the effects of implied motion on masculinity/femininity judgments in Experiment 1 in spite of greater sample size.

Results

Dynamism Judgments

The three-way Posture × Gender × Typicality repeated-measures ANOVA on dynamism judgments (**Figure 3**) showed a significant main effect of Posture [$F_{(1,20)}$ = 211.22; p < 0.001; η^2_p = 0.914], with higher dynamism judgments for dynamic than static poses. Interestingly, the ANOVA also revealed a significant main effect of Gender [$F_{(1,20)}$ = 6.16; p = 0.02; η^2_p = 0.236], demonstrating that female stimuli were judged as less dynamic than the male ones, even if displaying the same poses. However, a significant Posture × Gender × Typicality interaction [$F_{(1,19)}$ = 7.51; p = 0.01; η^2_p = 0.283] indicated that the dynamism judgments of female and male stimuli were modulated not only by the displayed body posture but also by gender typicality. Tukey *post-hoc* comparisons [MSE = 0.01886; *df* = 20] showed that female bodies were judged less dynamic than male bodies only when they were displayed in a dynamic posture

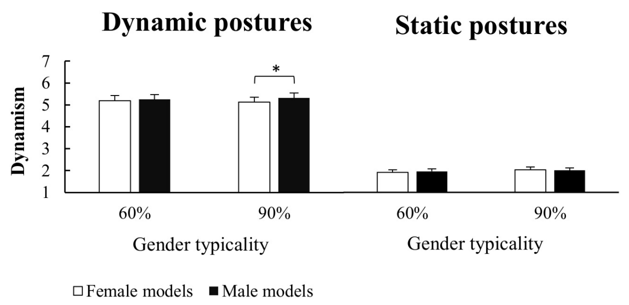

FIGURE 3 | Mean and standard error of mean for Dynamism judgment of Dynamic and Static postures as a function of gender (female/male) along the two categories of sex-typing traits expressed (60%/90%). Asteriks indicate significant pairwise comparisons.

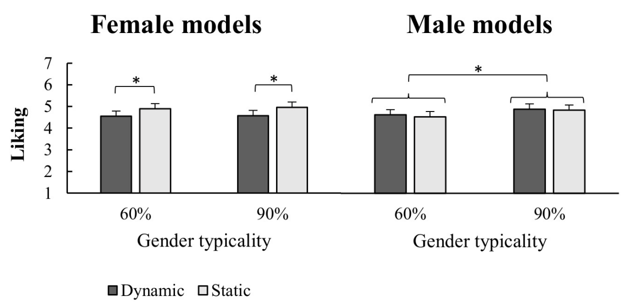

FIGURE 4 | Mean and standard error of mean for Liking judgment of Female and Male models as a function of implied motion (static/dynamic) along the two categories of sex-typing traits expressed (60%/90%). Asteriks indicate significant pairwise comparisons.

and with a 90% gender typicality (p = 0.005); conversely, no between-gender differences were obtained for the other figure types (all ps > 0.84). Furthermore, dynamic poses received higher dynamism judgments than static poses for all stimuli (all ps < 0.001), while for either male or female models, the 60% figures received comparable dynamism judgments to the 90% ones (all ps > 0.45).

Liking Judgments

The ANOVA on the aesthetic judgment values (**Figure 4**) showed a significant main effect of Typicality [$F_{(1,20)}$ = 8.55; p = 0.008; η_p^2 = 0.299], further qualified by a Gender × Typicality interaction [$F_{(1,20)}$ = 10.74; p = 0.004; η_p^2 = 0.349]. Tukey *post-hoc* test [MSE = 0.05433; df = 20] revealed that 90% male stimuli were judged more pleasant than the 60% ones (p < 0.001), while no typicality modulation of the liking judgments was obtained for the female stimuli (p = 0.822). Furthermore, less typical (i.e., 60%) female stimuli were liked more than less typical male stimuli (p = 0.026), while no between-gender difference was found for the 90% typicality stimuli (p = 0.444). Importantly, we found a significant Posture × Gender interaction [$F_{(1,20)}$ = 9.59; p = 0.006; η_p^2 = 0.324], showing that also posture modulated the liking judgments of male and female bodies. Tukey *post-hoc* test comparisons [MSE = 0.020789; df = 20] indicated that female models were judged more pleasant in static than dynamic poses (p = 0.002), while no significant difference between static and dynamic poses for male models was found (p = 0.50).

Item Analysis

To further explore the relationship between gender typicality, dynamism and aesthetic appreciation, we switched the data from the participant into the stimulus space, averaging for each of the 180 stimuli the dynamism, liking, or gender judgments across the 21 participants who took part to both Experiments 1 and 2. Female and male stimuli were analyzed separately, considering the femininity judgments for female stimuli and masculinity judgments for male stimuli. A series of bivariate correlation analyses was performed within the two sets of stimuli. Within the female stimuli, the bivariate correlation analysis showed a significant positive correlation between Femininity and Liking judgments [r(80) = 0.58, p < 0.001], but a negative correlation between Dynamism and Liking judgments [r(80) = −0.35, p = 0.002]; furthermore, a negative correlation between Femininity and Dynamism judgments was also found [r(80) = −0.22, p = 0.047]. Within the male stimuli, results showed a significant positive correlation of Masculinity judgments with either Dynamism [r(80) = 0.23, p = 0.04] or Liking [r(80) = 0.65, p < 0.001] judgments, while dynamism did not significantly correlate with the liking of male bodies [r(80) = −0.072, p = 0.527]. In sum, the correlation analysis revealed that, for both male and female figures, greater gender typicality was associated with greater liking judgments. However, while dynamism was associated with greater masculinity judgments for male stimuli, more dynamic female stimuli were judged less feminine and less pleasant.

Considering the trine reciprocal correlation between femininity, dynamism, and aesthetic appreciation of female bodies, we conducted a mediation analysis in order to assess the relative role of femininity or dynamism in mediating the influence of the other variable on liking judgments of female stimuli. Thus, we used established methods of mediation analyses to understand whether the effect of the independent variable (IV) on the dependent variable (DV) could be explained by a mediator (M) (MacKinnon et al., 1995). In particular, in two separate models, we tested whether the femininity or the dynamism could mediate the influence on liking judgment, exerted respectively by the dynamism or the femininity variables (**Figure 5**). Mediation effects were tested using the Sobel test by applying the Goodman correction (Goodman, 1960; MacKinnon et al., 1995). One-tailed effects were tested since the direction of the mediation was predicted. In the first model (A), we speculated that the level of Femininity (M) could mediate the impact of the Dynamism (IV) expressed by a female body on its Liking (DV). Inserting Femininity as mediator, the model provided evidence for an indirect effect of Dynamism on Liking judgments, since the negative relation between Dynamism and Liking was significantly affected by the inclusion of Femininity as a mediator (z = −1.91, p = 0.05). Conversely, no evidence of mediation was obtained (z = 1.65, p = 0.1) in a second model (B), considering that the Dynamism (M) conveyed by a body could mediate the effect of Femininity (IV) and on its Liking (VD).

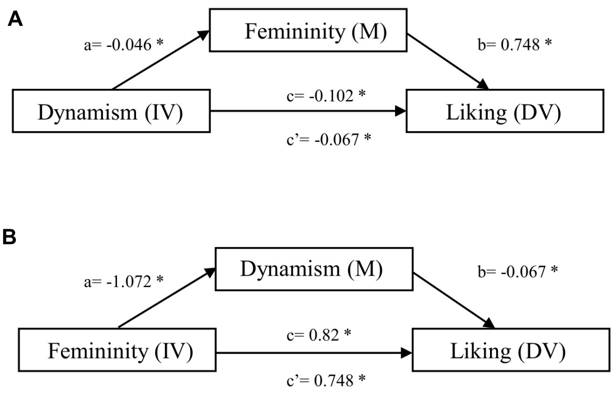

FIGURE 5 | Path diagrams illustrating the two mediation models. The first model (**A**, upper panel) tested whether Femininity could mediate the influence of Dynamism (IV) on Liking judgments. The second model (**B**, lower panel) tested whether Dynamism could mediate the influence of Femininity (IV) on Liking judgments. For each path, values correspond to the unstandardized path coefficients for the association between variables. Namely, path a represents the relationship between IV and M, and path b represents the relationship between M and DV (controlling for IV). Path c represents the direct effect between IV and DV. Lastly, the indirect effect of the mediator, path c′, was quantified as the difference between the unstandardized path coefficients of the direct effect between the independent and the DV (path c), and the product of the unstandardized path coefficients, a and b. Asterisks denote significant ($p < 0.05$) regression coefficient. Significant differences between the direct and the indirect effects resulted from Sobel test in model **(A)**, indicating that the negative relationship between Dynamism and Liking judgment is mediated by Femininity. Asteriks indicate significant pairwise comparisons.

Thus, mediation analyses suggested that more static female bodies were judged more feminine, leading to a more positive aesthetic appreciation.

Discussion

The aim of Experiment 2 was to investigate how gender typicality influences the perception of implied motion and how these two body cues interact in shaping the aesthetic appreciation of a human body. For this reason, participants rated male and female bodies varying in gender typicality for their level of dynamism and pleasantness. The results showed that gender typicality influences the perception of motion implied by a body posture. In particular, female bodies with 90% gender-typing morphological features were judged as less dynamic than male bodies even if they had the same postures. Notably, this gender asymmetry was not found for the low-typical (i.e., 60% typicality) body figures, thus demonstrating the crucial impact of the salience of sex-specific traits in perceiving the motion evoked by body postures. This further strengthens the association between stillness and femininity. Furthermore, Experiment 2 also showed that the compatibility between these morphological and motion cues to the perception of body gender influenced the aesthetic appreciation of bodies. Indeed, in general, the more typical, 90% models were liked more than the less typical, 60% bodies, confirming that typicality of body forms is associated with greater pleasantness (Johnson and Tassinary, 2007). This effect, however, appeared stronger when people were asked to judge a male model, indicating that the salience of gender-typing attributes may be more important in the appreciation of male beauty. Importantly, we also found that female models in static poses were judged more pleasant with respect to female models in dynamic poses. Since the pleasantness of a body increases with its capability to express gender-specific features (Johnson and Tassinary, 2007), the higher rate of pleasantness for static female bodies seems to be consistent with the idea that stillness could enhance femininity appearance. This was also corroborated by an item-level mediation analysis showing that more static female bodies were judged more feminine and this led to a more positive aesthetic appreciation.

GENERAL DISCUSSION

The present study aimed to investigate how the manipulation of gender-specific morphological features and implied motion of a body interact in its judgments. To this end, we asked participants to rate the masculinity and femininity (Experiment 1) or the dynamism and pleasantness (Experiment 2) of a series of pictures depicting male and female bodies expressing different amounts of gender-typing features (60% vs. 90% typicality) and displayed in static or dynamic postures. As expected, participants assigned higher value of masculinity and femininity to more gender-typical male and female bodies, respectively. However, the most interesting finding was that also implied motion influenced the gender judgment of body figures, at least when they were displayed with less gender-typing features (i.e., 60% typicality). Indeed, participants tended to perceive low-typical female bodies as more feminine when displayed in static than dynamic poses and to perceive low-typical male bodies as more masculine in dynamic than static poses. Crucially, however, not only implied motion influenced the perception of the gender-typing features of a body figure, but also gender typicality influenced the perception of motion conveyed by a body posture. Indeed, we found that models with typical female-typing features were evaluated as less dynamic than models with typical male-typing features, even when they displayed the same pose. This pattern of results suggests that gender-typing morphological cues and implied motion interact in shaping the perception of body gender. When morphological cues are not clear, the perception of static or dynamic postures pushes gender perception toward a female or male body, respectively. In a similar vein, when the motion conveyed by a body is fuzzy (e.g., implied motion in body pictures), the perception of female- or male-typing features pushes motion perception toward stillness or dynamism, respectively.

Importantly, we also found, at both subject- and item-level analyses, that the association between stillness and femininity influenced the aesthetic appreciation of a body. Indeed, bodies with more gender-typing features (i.e., 90% typicality) were liked more than less-typical bodies (60% typicality). This is in line with the notion that the stereotypical representation of the body according to its gender has implications for its aesthetic appreciation (McCreary et al., 2005), reflecting a correlation between gender-typing features and the impression of a good-looking body (Johnstone, 1994; Grammer et al., 2003; Singh and Singh, 2011). However, we also found that, within female figures, the models in static poses were evaluated as more pleasant than those in dynamic poses. This may seem in contrast with studies showing that more dynamic dance poses are liked more (Calvo-Merino et al., 2008; Cross and Ticini, 2012; Kirsch et al., 2016) and that implied motion enhances the aesthetic appreciation of human bodies (Cazzato et al., 2012), in terms of either attribution of intrinsic perceptual properties to the stimulus (i.e., beauty) or observer's attitude to it (i.e., liking or attractiveness). However, albeit gender-typical features were less salient in these previous studies as compared to our study, implied motion was found to be a better predictor of the aesthetic appreciation of male than female bodies (Cazzato et al., 2012). In addition, the different impact of static and dynamic stimuli in the judgment of female physical attractiveness has already been reported in adult actresses, showing that more feminine WHRs and larger breasts are considered desirable traits in static photographs whereas more androgynous body shapes are considered appropriate in stars that perform in movies (Voracek and Fisher, 2006). Here we found that static postures increased the aesthetic appreciation of female bodies. This effect could be due to a direct negative effect of implied motion on the appreciation of female attractiveness or be indirectly mediated by a masking of female-typical physical traits. However, the item mediation analysis allowed us to better delineate the relationship between femininity perception, stillness and aesthetic appreciation. In particular, we tested two models, based on the hypothesis that either stillness increased the perceived femininity of a female body and thus increased its pleasantness (Model A) or that femininity reduced the implied motion of a female body and thus reduced its pleasantness (Model B). The results provided evidence in favor of the first model, since perception of femininity was a key mediator of the negative relation between implied motion and liking. In other words, the effect of implied motion on the liking judgments of female bodies was better explained by an indirect effect mediated by femininity than by a direct effect of implied motion on liking. This supports the claim that stillness increased the aesthetic appreciation of a female body at least partially because it increased its gender typicality, likely facilitating the perception of feminine-typing features. In sum, our data suggest that femininity and stillness, on one hand, and masculinity and dynamism, on the other hand, are associated features in body representation, confirming clues from both sexual-selection and socio-cultural frameworks.

In a sexual-selection evolutionist framework, perceiving a static female body vs. a dynamic male body may boost the salience of gender-typing physical traits, such as WHR for women and muscularity for men. Numerous studies, indeed, have shown that a female body is strongly defined by the WHR, since it appears to be related to objective gender-specific qualities such as the levels of sex hormones (e.g., estradiol; De Ridder et al., 1990; Mondragón-Ceballos et al., 2015), the accessibility to fat resources suitable for fetal neurodevelopment (Lassek and Gaulin, 2008), and the more general capacity to sustain pregnancy (Singh, 1993). Obviously, WHR might only serve as a proxy for covariating bodily traits that shape the entire body phenotype and co-determine the judgment of body attractiveness (Brooks et al., 2015). Certainly, being able to select these qualities on the basis of visual cues increases the reproductive success of the species and, in this respect, the body shape of a woman could be considered as the best way to rapidly infer her femininity, meant as a set of biologically determined attributes. Since WHR is based on the computation of the waist and hip proportions, it is plausible that movements may affect its estimation altering shape and size perception. A body in motion, indeed, can provide misleading information about shape, for instance by producing overlaps of body parts (i.e., arms that cover hips while running). As shown in a recent eye-tracking study (Pazhoohi et al., 2020), WHR is widely view-dependent and movement pattern can cause variation in WHR detection, even if body proportions remain constant. On this view, dynamism may hinder the expression of the femininity of a woman by obscuring her salient shapes as compared to when staying in canonical static poses.

Conversely, as in many animal species, humans show sex differences in body composition and the amount of muscle mass appears to be greater in men than in women (Wells, 2007). Performing actions may accentuate the perception of body muscularity, thus biasing gender perception toward masculinity. Furthermore, male individuals seem to tend to disclose their masculinity right through movements (Darwin, 1871), as demonstrated by males of some species which use dance as a signal of neuromuscular condition (Maynard Smith, 1956) or flight ability (Williams, 2001). In humans, for example, it has been shown that men's bodily symmetry, a measure that reflects the developmental stability of an organism (Moller and Swaddle, 1997; Polak, 2003) and preservation from morbidity and mortality (Stevenson, 2000), strongly correlates with their dance ability (Brown et al., 2005) and running performance (Manning and Pickup, 1998). This suggests that movements, rather than shape, may be a better predictor of men's functional effectiveness.

As a legacy of sexual selection, the stereotypical association between femininity/stillness and masculinity/dynamism is reflected in socio-cultural norms, grounded on how people think men and women should differ. A domain in which this distinction is quite tangible is represented by sports context. Indeed, studies have suggested that, in most of Western countries, girls and women are less encouraged to participate in sports than boys and men (Eccles and Harold, 1991; Hartmann-Tews and Pfister, 2003) and, even in physical activities where women are predominant, such as performing arts (i.e., ballet), performance seems to be judged more on the basis of aesthetic features than body capability (Klomsten et al., 2005). Nevertheless, media images in sports endorses the stereotyped view of men's and women's bodies, emphasizing strength and physical abilities in the case of male athletes but featuring female performers in terms of a sexualized body (Von Der Lippe, 2002). This is in line with the present finding that perception of femininity appears to be intensified by a static body pose. In this regard, studies about "woman objectification," which refers to the tendency to perceive a woman worth in light of her body appearance and sexual function, have demonstrated that the identification of the female body as an object available for satisfying the needs of men may diminish her attribution of agency (Cikara et al., 2011) and, consequently, underline her passive condition. Interestingly, recent researches have shown that images of female bodies are processed as a recollection of body parts rather than a whole figure (Bernard et al., 2012, 2015), a fragmentary process that is generally observed in the recognition of objects; notably, this pattern of visual perception occurs independently from the gender of the observer, demonstrating that such objectification of the female body involves women themselves. Thus, the well-proved association between femininity and object-related features could easily explain why static postures make bodies to appear more feminine. At the same time, men are encouraged to display their sex-typing features in keeping with contemporary masculine norms, which consider increased muscle mass as more masculine (Mishkind et al., 1986; McCreary et al., 2005). This may explain why men tend to express their gendered body through exercising and practicing physical activity. Accordingly, a study aimed at exploring the association between levels of exercise and patterns of masculinity in men undergoing androgen deprivation therapy has recently revealed that men who are aerobically active have higher levels of self-reported masculinity than those who are inactive (Langelier et al., 2018), highlighting the intersection of masculinity and physical activity. Further, women also seem to judge masculinity through body movements, since they assess a man's physical strength and attractiveness on the basis of his gait (Fink et al., 2016).

The conclusions that can be drawn from this study need to be weighted in the light of important limitations. First of all, we investigated the effects of dynamic cues in body perception by using static pictures of bodies with implied motion. This allowed controlling for the amount of body views offered in videos of a moving or still person, but obviously limits the salience and naturalness of body movements. Nevertheless, there is evidence for common neurocognitive representation of actual and implied body movements (Urgesi et al., 2006; Cazzato et al., 2014, 2016). Furthermore, the limited sample size prevented us from examining differences between male and female observers and to generally explore the role of individual differences in body-related processes on the association between stillness, femininity, and aesthetic appreciation of bodies. However, in keeping with previous findings (Bernard et al., 2012, 2015), our analyses showed overlapping pattern of results in male and female participants, at least in Experiment 1 where the effects of implied motion on masculinity/femininity perception were explored. Further studies with larger sample are required to appropriately test for gender effects in body perception. Furthermore, we found overlapping results not only when data were treated at the subject level, thus aiming at generalizing at wider population of male and female observers, but also at the item level, thus aiming at generalizing the results at a wider population of male and female bodies. The use of only a limited number of variations in gender typicality (i.e., 60% vs. 90%) prevents us from describing the effect of implied motion on female and male bodies along the continuous nature of gender typicality. Future studies, thus, need to test a larger sample and use different types of stimuli (e.g., videos of real rather than computer-generated bodies in movements) with greater variations of gender typicality and greater ecological validity in order to shed light on whether the association between stillness and femininity concerns mostly perceptive mechanisms or the stereotypical meaning assigned to men and women.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Comitato Etico Regionale Unico. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

GD'A, AF, and CU conceived and designed the study. GD'A collected and analyzed the data and wrote the first draft of the manuscript. All authors revised and approved the final version of the manuscript.

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REFERENCES

Archer, J. (2009). Does sexual selection explain human sex differences in aggression? *Behav. Brain Sci.* 32, 249–311. doi: 10.1017/S0140525X09990951

Bernard, P., Gervais, S., Allen, J., Campomizzi, S., and Klein, O. (2015). From sex objects to human beings: masking sexual body parts and humanization as moderators to women 's objectification. *Psychol. Women Quart.* 674, 15.

Bernard, P., Gervais, S. J., Allen, J., Campomizzi, S., and Klein, O. (2012). Integrating sexual objectification with object versus person recognition: the sexualized-body-inversion hypothesis. *Psychol. Sci.* 23, 469–471. doi: 10.1177/0956797611434748

Blaivas, J. G., Levine, M. P., and Murnen, S. K. (2002). The effect of experimental presentation of thin media images on body satisfaction: a meta-analytic review. *Int. J. Eating Disord.* 31, 1–16. doi: 10.1002/eat.10005

Brooks, R. C., Shelly, J. P., Jordan, L. A., and Dixson, B. J. (2015). The multivariate evolution of female body shape in an artificial digital ecosystem. *Evol. Hum. Behav.* 36, 351–358.

Brown, W. M., Cronk, L., Grochow, K., Jacobson, A., Liu, C. K., Popovic, Z., et al. (2005). Dance reveals symmetry especially in young men. *Nature* 504, 470. doi: 10.1038/nature04344

Calvo-Merino, B., Jola, C., Glaser, D. E., and Haggard, P. (2008). Towards a sensorimotor aesthetics of performing art. *Consciousn. Cognit.* 17, 911–922. doi: 10.1016/j.concog.2007.11.003

Cazzato, V., Mian, E., Mele, S., Tognana, G., Todisco, P., and Urgesi, C. (2016). The effects of body exposure on self-body image and esthetic appreciation in anorexia nervosa. *Exp. Brain Res.* 234, 695–709. doi: 10.1007/s00221-015-4498-z

Cazzato, V., Mian, E., Serino, A., Mele, S., and Urgesi, C. (2014). Distinct contributions of extrastriate body area and temporoparietal junction in perceiving one's own and others' body. *Cognit. Affect. Behav. Neurosci.* 15, 211–228. doi: 10.3758/s13415-014-0312-9

Cazzato, V., Siega, S., and Urgesi, C. (2012). "What women like": influence of motion and form on esthetic body perception. *Front. Psychol.* 3:235. doi: 10.3389/fpsyg.2012.00235

Cikara, M., Eberhardt, J. L., and Fiske, S. T. (2011). From agents to objects: sexist attitudes and neural responses to sexualized targets. *J. Cognit. Neurosci.* 23, 540–551. doi: 10.1162/jocn.2010.21497

Cooky, C., Messner, M. A., and Musto, M. (2015). It's Dude Time!: a quarter century of excluding women's sports in televised news and highlight shows. *Commun. Sport* 3, 261–287. doi: 10.1177/2167479515588761

Cross, E. S., and Ticini, L. F. (2012). Neuroaesthetics and beyond: new horizons in applying the science of the brain to the art of dance. *Phenomenol. Cognit. Sci.* 11, 5–16. doi: 10.1007/s11097-010-9190-y

Daniel, S., and Bridges, S. K. (2010). The drive for muscularity in men: media influences and objectification theory. *Body Image* 7, 32–38. doi: 10.1016/j.bodyim.2009.08.003

Darwin, C. (1871). *The Descent of Man and Selection in Relation to Sex*. Cambridge: Cambridge University Press.

De Ridder, C. M., Bruning, P. F., Zonderland, M. L., Thijssen, J. H. H., Bonfrer, J. M. G., Blankenstein, M. A., et al. (1990). Body fat mass, body fat distribution, and plasma hormones in early puberty in females. *J. Clin. Endocrinol. Metabol.* 70, 888–893. doi: 10.1210/jcem-70-4-888

Dixon, B. J., Dixson, A. F., Li, B., and Anderson, M. J. (2007). Studies of human physique and sexual attractiveness: sexual preferences of men and women in China. *Am. J. Hum. Biol.* 19, 88–95. doi: 10.1002/ajhb.20584

Dixson, B. J., Grimshaw, G. M., Linklater, W. L., and Dixson, A. F. (2011). Eye-tracking of men's preferences for waist-to-hip ratio and breast size of women. *Arch. Sex. Behav.* 40, 43–50. doi: 10.1007/s10508-009-9523-5

Dixson, B. J., Grimshaw, G. M., Ormsby, D. K., and Dixson, A. F. (2014). Eye-tracking women's preferences for men's somatotypes. *Evol. Hum. Behav.* 35, 73–79. doi: 10.1016/j.evolhumbehav.2013.10.003

Drummond, M. (2008). Sport, aging men, and constructions of masculinity. *Generations* 32, 32–35.

Eccles, J. S., and Harold, R. D. (1991). Gender differences in sport involvement: applying the eccles' expectancy-value model. *J. Appl. Sport Psychol.* 3, 7–35. doi: 10.1080/10413209108406432

Fejes, I., Koloszár, S., Szöllosi, J., Závaczki, Z., and Pál, A. (2005). Is semen quality affected by male body fat distribution? *Andrologia* 37, 155–159. doi: 10.1111/j.1439-0272.2005.00671.x

Fink, B., André, S., Mines, J. S., Weege, B., Shackelford, T. K., and Butovskaya, M. L. (2016). Sex difference in attractiveness perceptions of strong and weak male walkers. *Am. J. Hum. Biol.* 28, 913–917. doi: 10.1002/ajhb.22891

Goodman, L. A. (1960). On the exact variance of products. *J. Am. Stat. Assoc.* 55, 708–713. doi: 10.1080/01621459.1960.10483369

Grabe, S., Ward, L. M., and Hyde, J. S. (2008). The role of the media in body image concerns among women: a meta-analysis of experimental and correlational studies. *Psychol. Bull.* 134, 460–476. doi: 10.1037/0033-2909.134.3.460

Grammer, K., Fink, B., Møller, A. P., and Thornhill, R. (2003). Darwinian aesthetics: sexual selection and the biology of beauty. *Biol. Rev. Cambridge Philos. Soc.* 78, 385–407. doi: 10.1017/S1464793102006085

Hartmann-Tews, I., and Pfister, G. (2003). *Women's Inclusion in Sport: International and Comparative Findings,* eds G. Hartmann-Tews and I. Pfister. New York, NY: Routledge.

Hawkins, N., Scott Richards, P., Granley, H., Mac, and Stein, D. M. (2004). The impact of exposure to the thin-ideal media image on women. *Eat. Disord.* 12, 35–50. doi: 10.1080/10640260490267751

Hovden, J., von der Lippe, G. (2019). The gendering of media sport in the Nordic countries. *Sport Soc.* 22, 625–630. doi: 10.1080/17430437.2017.1389046

Hugill, N., Fink, B., and Neave, N. (2010). The role of human body movements in mate selection. *Evol. Psychol.* 8, 66–89.

Hugill, N., Fink, B., Neave, N., Besson, A., and Bunse, L. (2011). Women's perception of men's sensation seeking propensity from their dance movements. *Personal. Ind. Diff.* 51, 483–487. doi: 10.1016/j.paid.2011.05.002

Hugill, N., Fink, B., Neave, N., and Seydel, H. (2009). Men's physical strength is associated with women's perceptions of their dancing ability. *Personal. Ind. Diff.* 47, 527–530. doi: 10.1016/j.paid.2009.04.009

Johnson, K. D. (2004). Perceiving people: Interpersonal meaning in the body's motion and morphology. *Sci. Eng* 16, 890–897.

Johnson, K. L., Iida, M., and Tassinary, L. G. (2012). Person (mis)perception: functionally biased sex categorization of bodies. *Proc. R. Soc. B Biol. Sci.* 279, 4982–4989. doi: 10.1098/rspb.2012.2060

Johnson, K. L., and Tassinary, L. G. (2005). Perceiving sex directly and indirectly: meaning in motion and morphology. *Psychol. Sci.* 16, 890–897. doi: 10.1111/j.1467-9280.2005.01633.x

Johnson, K. L., and Tassinary, L. G. (2007). Compatibility of basic social perceptions determines perceived attractiveness. *Proc. Natl. Acad. Sci. U.S.A.* 104, 5246–5251. doi: 10.1073/pnas.0608181104

Johnstone, R. A. (1994). Female preference for symmetrical males as a by-product of selection for mate recognition. *Nature* 372, 172–175. doi: 10.1038/372172a0

Kerrigan, D. C., Todd, M. K., and Della Croce, U. (1998). Gender differences in joint biomechanics during walking: normative study in young adults. *Am. J. Phys. Med. Rehabil.* 77, 2–7. doi: 10.1097/00002060-199801000-00002

Kirsch, L. P., Urgesi, C., and Cross, E. S. (2016). Shaping and reshaping the aesthetic brain: emerging perspectives on the neurobiology of embodied aesthetics. *Neurosci. Biobehav. Rev.* 62, 56–58. doi: 10.1016/j.neubiorev.2015.12.005

Klomsten, A. T., Marsh, H. W., and Skaalvik, E. M. (2005). Adolescents' perceptions of masculine and feminine values in sport and physical education: a study of gender differences. *Sex Roles* 52, 625–636. doi: 10.1007/s11199-005-3730-x

Kozlowski, L. T., and Cutting, J. E. (1977). Recognizing the sex of a walker from a dynamic point-light display. *Percept. Psychophys.* 21, 575–580. doi: 10.3758/BF03198740

Langelier, D. M., Cormie, P., Bridel, W., Grant, C., Albinati, N., Shank, J., et al. (2018). Perceptions of masculinity and body image in men with prostate cancer: the role of exercise. *Support. Care Cancer* 26, 3379–3388. doi: 10.1007/s00520-018-4178-1

Lassek, W. D., and Gaulin, S. J. C. (2008). Waist-hip ratio and cognitive ability: is gluteofemoral fat a privileged store of neurodevelopmental resources? *Evol. Hum. Behav.* 29, 26–34. doi: 10.1016/j.evolhumbehav.2007.07.005

Lippa, R. (1983). Sex typing and the perception of body outlines. *J. Personal.* 51, 667–682. doi: 10.1111/j.1467-6494.1983.tb00873.x

MacKinnon, D. P., Warsi, G., and Dwyer, J. H. (1995). A simulation study of mediated effect measures. *Multivar. Behav. Res.* 30, 41. doi: 10.1207/s15327906mbr3001_3

Manning, J. T., and Pickup, L. J. (1998). Symmetry and performance in middle distance runners. *Int. J. Sports Med.* 19, 205–259. doi: 10.1055/s-2007-971905

Mather, G., and Murdoch, L. (1994). Gender discrimination in biological motion displays based on dynamic cues. *Proc. R. Soc. B Biol. Sci.* 258, 273–279. doi: 10.1098/rspb.1994.0173

Mautz, B. S., Wong, B. B., Peters, R. A., and Jennions, M. D. (2013). Penis size interacts with body shape and height to influence male attractiveness. *Proc. Natl. Acad. Sci. U.S.A.* 110, 6925–6930.

Maynard Smith, J. (1956). Fertility, mating behaviour and sexual selection in Drosophila subobscura. *J. Genet.* 84, 17–35.

McCreary, D. R., Saucier, D. M., and Courtenay, W. H. (2005). The drive for muscularity and masculinity: testing the associations among gender-role traits, behaviors, attitudes, and conflict. *Psychol. Men Mascul.* 6, 83–94. doi: 10.1037/1524-9220.6.2.83

McDonnell, R., Jörg, S., Hodgins, J. K., Newell, F., and O'Sullivan, C. (2007). "Virtual shapers & movers: form and motion affect sex perception," in *Proceedings of the 4th Symposium on Applied Perception in Graphics and Visualization, APGV 2007*, (Tübingen), doi: 10.1145/1272582.1272584

Mishkind, M., Rodin, J., Silberstein, L., and Striegel-Moore, R. (1986). The embodiment of masculinity: cultural, psychological, and behavioral dimensions. *Am. Behav. Sci*. 29, 545–562. doi: 10.1177/000276486029005004

Moller, A., and Swaddle, J. (1997). *Developmental Stability and Evolution*. Oxford: Oxford University Press.

Mondragón-Ceballos, R., García Granados, M. D., Cerda-Molina, A. L., Chavira-Ramírez, R., and Hernández-López, L. E. (2015). Waist-to-hip ratio, but not body mass index, is associated with testosterone and estradiol concentrations in young women. *Int. J. Endocrinol.* 2015, 654046. doi: 10.1155/2015/654046

Neave, N., McCarty, K., Freynik, J., Caplan, N., Hönekopp, J., and Fink, B. (2011). Male dance moves that catch a woman's eye. *Biol. Lett.* 7, 221–224. doi: 10.1098/rsbl.2010.0619

Nicholson, L. (1994). Interpreting Gender. *Signs J. Women Cult. Soc*. 20, 79–105. doi: 10.1086/494955

Oldfield, R. C. (1971). The assessment and analysis of handedness: the edinburgh inventory. *Neuropsychologia* 9, 97–113. doi: 10.1016/0028-3932(71)90067-4

Pazhoohi, F., Macedo, A. F., Doyle, J. F., and Arantes, J. (2020). Waist-to-hip ratio as supernormal stimuli: effect of contrapposto pose and viewing angle. *Arch. Sex Behav*. 49, 837–847. doi: 10.1007/s10508-019-01486-z

Polak, M. (2003). *Developmental Instability: Causes and Consequences*. New York, NY: Oxford Univ. Press.

Sheets-Johnstone, M. (2005). Man has always danced": forays into the origins of an art largely forgotten by philosophers. *Contem. Aesthet*. 3.

Singh, D. (1993). Adaptive Significance of Female Physical Attractiveness: role of waist-to-hip ratio. *J. Personal. Soc. Psychol.* 65, 293–307. doi: 10.1037/0022-3514.65.2.293

Singh, D., and Singh, D. (2011). Shape and significance of feminine beauty: an evolutionary perspective. *Sex Roles* 64, 723–731. doi: 10.1007/s11199-011-9938-z

Sorokowski, P., and Sorokowska, A. (2012). Judgments of sexual attractiveness: a study of the yali tribe in papua. *Arch. Sex. Behav.* 41, 1209–1218. doi: 10.1007/s10508-012-9906-x

Stevenson, J. C. (2000). Asymmetry, developmental stability, and evolution. *Am. J. Hum. Biol*. 4, 53–55. doi: 10.1002/1520-6300(200009/10)12:5<720::aid-ajhb23<3.0.co;2-4

Sugiyama, L. S. (2004). Is beauty in the context-sensitive adaptations of the beholder? *Shiwiar use of waist-to-hip ratio in assessments of female mate value. Evol. Hum. Behav*. 25, 51–62. doi: 10.1016/S1090-5138(03)00083-7

Symons, D. K., and Buss, D. M. (1994). The evolution of desire: strategies of human mating. *J. Marriage Fam*. 56, 1052–1053. doi: 10.2307/353621

Tolman, D. L., Impett, E. A., Tracy, A. J., and Michael, A. (2006). Looking good, sounding good: femininity ideology and adolescent girls' mental health. *Psychol. Women Quart*. 30, 85–95. doi: 10.1111/j.1471-6402.2006.00265.x

Urgesi, C., Moro, V., Candidi, M., and Aglioti, S. M. (2006). Mapping implied body actions in the human motor system. *J. Neurosci.* 26, 7942–7949. doi: 10.1523/JNEUROSCI.1289-06.2006

Von Der Lippe, G. (2002). Media image: sport, gender and national identities in five European countries. *Int. Rev. Sociol. Sport* 37, 371–395. doi: 10.1177/1012690202037004029

Voracek, M., and Fisher, M. L. (2006). Success is all in the measures: androgenousness, curvaceousness, and starring frequencies in adult media actresses. *Arch. Sex. Behav.* 35, 297–304.

Wells, J. C. K. (2007). Sexual dimorphism of body composition. *Best Pract. Res*. 21, 415–430. doi: 10.1016/j.beem.2007.04.007

Williams, H. (2001). Choreography of song, dance and beak movements in the zebra finch (Taeniopygia guttata). *J. Exp. Biol*. 204, 3497–3506.

Windhager, S., Schaefer, K., and Fink, B. (2011). Geometric morphometrics of male facial shape in relation to physical strength and perceived attractiveness, dominance, and masculinity. *Am. J. Hum. Biol.* 23, 805–814. doi: 10.1002/ajhb.21219

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Neural Correlates of Own- and Other-Face Perception in Body Dysmorphic Disorder

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Background: Body dysmorphic disorder (BDD) is characterized by an excessive preoccupation with one or more perceived flaws in one's own appearance. Previous studies provided evidence for deficits in configural and holistic processing in BDD. Preliminary evidence suggests abnormalities at an early stage of visual processing. The present study is the first examining early neurocognitive perception of the own face in BDD by using electroencephalography (EEG). We investigated the face inversion effect, in which inverted (upside-down) faces are disproportionately poorly processed compared to upright faces. This effect reflects a disruption of configural and holistic processing, and in consequence a preponderance of featural face processing.

Methods: We recorded face-sensitive event-related potentials (ERPs) in 16 BDD patients and 16 healthy controls, all unmedicated. Participants viewed upright and inverted (upside-down) images of their own face and an unfamiliar other face, each in two facial emotional expressions (neutral vs. smiling). We calculated the early ERP components P100, N170, P200, N250, and the late positive component (LPC), and compared amplitudes among both groups.

Results: In the early P100, no face inversion effects were found in both groups. In the N170, both groups exhibited the common face inversion effects, with significantly larger N170 amplitudes for inverted than upright faces. In the P200, both groups exhibited larger inversion effects to other (relative to own) faces, with larger P200 amplitudes for other upright than inverted faces. In the N250, no significant group differences were found in face processing. In the LPC, both groups exhibited larger inversion effects to other (relative to own) faces, with larger LPC amplitudes for other inverted than upright faces. These overall patterns appeared to be comparable for both groups. Smaller inversion effects to own (relative to other) faces were observed in none of these components in BDD, relative to controls.

Conclusions: The findings suggest no evidence for abnormalities at all levels of early face processing in our observed sample of BDD patients. Further research should investigate the neural substrates underlying BDD symptomatology.

Keywords: body dysmorphic disorder, own-face perception, face inversion effect, event-related potentials, electroencephalography

INTRODUCTION

A large body of research supports that faces are processed holistically in healthy humans (1, 2). Research indicates that the perception of a specific part is not independent of other parts, and that faces are processed as a gestalt whole (3, 4). Clinical researchers showed heightened interest in abnormalities in holistic face processing in psychiatric disorders. Body dysmorphic disorder (BDD) is characterized by an excessive preoccupation with perceived defect(s) or flaws in one's own physical appearance which are not observable or appear slight to others (5). This preoccupation often pertains to the own face in particular. Individuals with BDD focus on details in the appearance of their skin, hair, or other facial parts (6). They believe that these features are disfigured or ugly and often have delusional beliefs (7). Some individuals experience high levels of suffering and distress. BDD is often accompanied by high psychiatric comorbidity (8), suicidality (9), low quality of life, and can result in severe psychosocial impairments (10).

Neuropsychological and cognitive-behavioral models emphasize the potential role of a detailed perception in the maintenance of BDD [e.g., (11–13)]. Behavioral studies with different experimental paradigms using own-face (14), own- and other-face (15, 16), and other-face (17) stimuli provided evidence for a high aestethic sensitivity, enhanced discrimination abilities [but see (18, 19)], and a selective attention toward perceived flaws in BDD [e.g., (20, 21)]. Neuroimaging studies indicate a detailed processing of faces and an aberrant processing of configural and holistic information in BDD (22, 23). However, it remains unclear whether the abnormal brain activation patterns are primarily the result of an aberrant early visual cortex activity or of a modulation by prefrontal and/or limbic systems (24). In an electroencephalography (EEG) study, evidence was found for significantly smaller N170 amplitudes in BDD, compared to healthy controls, for normal images, regardless of stimulus type (faces or houses) (24). There was also a trend for longer N170 latencies, regardless of spatial frequency or stimulus type. These findings may suggest perceptual abnormalities at an early stage of visual processing in BDD. A later study assessing EEG and fMRI (25) found that compared to healthy controls, individuals with BDD and anorexia nervosa demonstrated similar hypoactivity in early secondary visual processing regions including lateral occipital cortex (linked to the N170 component), occipital pole and precuneus for low spatial frequency (i.e., low-detail) faces, indicating abnormal spatiotemporal activation of configural and holistic information in BDD.

A paradigm providing insight into configural and holistic face processing is the face inversion effect (26). Previous research suggests that upright faces are processed with the use of configural information by forming a holistic face representation, whereas inverted faces tend to be processed by using featural information in face-sensitive brain regions (27, 28). In healthy humans, inverting a face disrupts configural and holistic face processing, and has no (or less) influence on the processing of featural information (29). Four behavioral studies investigated the face inversion effect in BDD, yielding inconsistent results. Whereas Feusner et al. (30) and Mundy and Sadusky (31) found smaller inversion effects, and Jeffries et al. (32) a superior recognition of inverted famous faces in BDD, relative to controls, all suggesting a greater detailed processing, no differences were found by Monzani et al. (33). However, different experimental conditions (e.g., presentation time), variation in stimuli (e.g., familiarity), sample characteristics (e.g., different degrees of BDD severity) or insufficient statistical power might explain the inconsistent findings.

Building on previous studies and using an established paradigm (34), we neurophysiologically determined whether or not any potential face inversion effects are specific to own faces in BDD. Smaller face inversion effects to own faces would be in line with the interpretation that holistic processing of own faces is specifically compromised in BDD. We assessed the following early ERP components [cf. (35)]: (1) The occipito-temporal P100 is related to the processing of low-level physical characteristics (36), occurs about 80–120 ms poststimulus (37), and was assessed to investigate processes preceding face detection and structural encoding. (2) The occipito-temporal N170 is sensitive to face inversion, with larger amplitudes and delayed latencies for inverted than upright faces [e.g., (38, 39)], and occurs about 150–180 ms poststimulus. Larger N170 amplitudes for inverted faces reflect a disruption of configural processing and a preponderance of featural processing. The N170 is modulated by "self-information," and more negative for own relative to other faces [e.g., (40, 41)]. (3) The occipito-temporal P200 occurs about 200–250 ms poststimulus, has been related to the perceived typicality of a face [e.g., (40, 42, 43)], and is larger for less distinctive (i.e., more typical) faces. (4) The occipito-temporal N250 component is responsive to face familiarity [e.g., (44, 45)], occurs about 260–400 ms poststimulus. (5) The centro-parietal late positive component (LPC) occurs about 400–600 ms poststimulus, and has been related to the activation and recognition of emotional content of stimuli [e.g., (46)].

In line with previous research in BDD (24, 25), on the P100, we hypothesized smaller P100 amplitudes in BDD, compared to healthy controls, which would reflect abnormal early configural processing. On the N170 component, we predicted smaller N170 inversion effects to own (relative to other) faces in BDD, compared to healthy controls, with smaller amplitudes for own inverted than upright faces, as we hypothesized predominantly featural processing of own faces not only in inverted but already in upright faces in BDD. On the P200 component, we expected smaller P200 inversion effects to own (relative to other) faces in BDD, compared to healthy controls, with smaller P200 amplitudes for own inverted than upright faces, which would reflect predominantly featural processing and a lower perceived typicality of the own face (i.e., the own face is perceived as less typical and more distinctive) in BDD. In the N250 component, we expected smaller N250 inversion effects to own (relative to other) faces in BDD, compared to controls, and larger N250 amplitudes for own (relative to other) faces in BDD, which would reflect a higher familiarity with the own face that may result from a permanent preoccupation with perceived defects in the own face. In the LPC component, we expected smaller LPC inversion effects to own (relative to other) faces in BDD, compared to controls, and larger LPC amplitudes for own (relative to other) faces, which would reflect a less efficient emotional recognition of own faces in BDD. Dependent variables were the amplitudes on the P100, N170, P200, N250, and the LPC components.

MATERIALS AND METHODS

Participants

The EEG study was part of a research program in which we also investigated adaptive face coding mechanisms in BDD (results are reported elsewhere). Participants were recruited between 2012 and 2015 *via* an outpatient unit at Goethe University Frankfurt, Germany, and *via* flyers that we posted in coffee shops, at university, or libraries, and sent to psychotherapists, plastic surgeons, and dermatologists for distribution to their patients. All participants were age- and gender-matched. BDD patients had a primary diagnosis of BDD confirmed by a licensed clinical psychologist (VR) administering the German version of the Structured Clinical Interview for DSM-IV-TR [SCID; (47, 48)], the German version of the clinician-administered BDD Diagnostic Module [BDDDM; (49, 50)], and the German version of the clinician-administered BDD Modification of the Yale-Brown Obsessive-Compulsive Scale [BDD-YBOCS; (49, 51)]. Given that the BDD-YBOCS was developed for clinical samples of BDD patients (52), the measure was administered to BDD participants only. The following self-report measures were applied: the Body Dysmorphic Symptoms Inventory [FKS; Fragebogen Körperdysmorpher Symptome; (53)], the German version of the Beck Depression Inventory-II [BDI-II; (54, 55)], and the German version of the Brief Symptom Inventory [BSI; (56, 57)].

BDD Inclusion/Exclusion Criteria

The study protocol was approved by the ethics committee of the Medical Faculty of the Goethe University Frankfurt (Ref. No. 39/11) and conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants. Individuals who met diagnostic criteria for BDD as determined by the BDDDM, and who scored higher or equal to 20 on the BDD-YBOCS (52) were eligible. In order to comprise a clinically representative sample, all concurrent Axis I disorders less severe than BDD were permitted except those listed among the following exclusion criteria: current or past obsessive-compulsive and related disorders, a history of psychotic or bipolar disorders, suicidality, concurrent psychotherapeutic, and psychopharmacological treatment.

HC Inclusion/Exclusion Criteria

Healthy controls showed no current or past Axis-I psychiatric history, as determined by the SCID. All participants (BDD and HC) had normal or corrected to normal vision and all but one was right-handed as determined by the Edinburgh Inventory (58).

Stimuli and Apparatus

Stimuli consisted of 10 different images of the own face and 10 different images of an unfamiliar gender- and age-matched face, which were prepared under standardized conditions using a digital camera. The 10 images showed each face in five different orientations: frontal view, 22.5° left or right side and 45° left or right side; this was done to increase variability of stimuli and to discourage a processing strategy that focusses on individual images, rather than faces. Each orientation was shown with either neutral or smiling expressions. The facial emotional expression “smiling” was chosen to increase the number of stimuli, and to take into account previous research which found biases in processing of facial emotional expressions in BDD [e.g., (32, 59)]. Where necessary, stimuli were transformed to approximately equal luminance and contrast, and any information from the neck downwards, such as clothing, and accessories were removed. Raw pictures were adjusted to 170 × 260 pixels.

Overall, 20 images were used for experimental trials, each in upright or inverted position, resulting in 40 different stimuli for experimental trials. In addition, ten images of another gender-matched unfamiliar face (each in the five different orientations, neutral or smiling expression, upright, or inverted) were used as stimuli for 20 practice trials. Stimulus examples are given in **Figure 1**.

All stimuli were presented on a dark gray screen in the center of a 19” Samsung SyncMaster 795DF CFT-monitor. The presentation software was Eprime™ (Version 2). Stimuli were presented at a viewing distance of 90 cm, which was kept constant by using a chin rest (visual angle 5.4° × 6.9°).

Experimental Procedure

At the beginning of the experiment, participants received written instructions on the screen. They were instructed to decide whether the presented face is either in a veridical (upright) or in an inverted position, by pressing marked keys (“f” and “j”) on a standard keyboard (German layout) using the index fingers of both hands. Note that our rationale for the present task was that we wished ensure that participants had attentively processed the stimuli, while at the same time the task itself should *not* direct participants´ attention to the identity of the face (own or other). Accordingly, we reasoned that any differences in neural

FIGURE 1 | Stimulus examples of one male identity. The images show the 20 different faces (frontal view, 22.5° left and right side, 45° left and right side each with neutral and smiling expression, upright and inverted position).

processing of own and other face reflected spontaneous processing differences, with no interference from the specific task demands.

The experiment consisted of a practice phase (20 trials) and an immediately following test phase. The test phase consisted of 10 blocks (400 trials), each block containing stimuli of each condition (five different face orientations, upright vs. inverted position, own vs. other face, neutral vs. smiling expression). Within blocks, stimuli were presented in randomized order. Between blocks, participants were allowed a self-paced break. Each trial started with a fixation cross (2,000 ms), followed by a face (1,000 ms) and another fixation cross (2,000 ms) [in accordance with (34)]. A schematic sequence of the experiment is given in **Figure 2**.

EEG Acquisition

EEG data were recorded in an electrically and acoustically shielded room with sintered Ag/AgCl electrodes mounted in an electrode cap (EasyCap™, Herrsching-Breitbrunn, Germany) using a BioSemi Active II System (BioSemi, Amsterdam, Netherlands). Thirty-two electrodes were arranged according to an extended 10/20 system at the scalp positions Fz, Cz, Pz, Iz, FP1, FP2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T7, T8, P7, P8, F9, F10, FT9, FT10, TP9, TP10, P9, P10, PO9, PO10, I1, and I2. The horizontal electrooculogram (EOG) was recorded from F9' and F10' at the outer canthi of both eyes. The vertical EOG was monitored bipolarly from electrodes above and below the right eye. Signals were recorded with DC (120 Hz, −6 dB attenuation, 12 dB/octave), and sampled at 512 Hz.

Offline, ocular artifacts were automatically corrected using BESA™ 5.1 (60). Epochs were generated, lasting 1,200 ms, including a 200-ms prestimulus baseline interval. In the test phase, we analyzed only trials with correct responses. Trials contaminated by nonocular artifacts were rejected from further analysis using the BESA™ artifact rejection tool (amplitude threshold 100 µV, gradient criterion 50 µV). The EEG was low-pass filtered at 40 Hz, and recalculated to average reference, excluding vertical and horizontal EOG channels. Trials were averaged separately for each channel and experimental condition (own and other, upright and inverted, neutral and smiling faces). The average numbers of correct and artifact-free trials over all conditions in the test phase were 44.4 and 43.8 for BDD patients and healthy controls, respectively.

ERPs were quantified using mean amplitudes for the occipito-temporal P100 (80–120 ms), N170 (120–164 ms), P200 (195–225ms) and N250 (250–340ms) components, as well as for a centro-parietal LPC (400–600 ms), all relative to the 200-ms prestimulus baseline. Time intervals were selected based on previous research and visual inspection of the grand mean ERPs. Effects were quantified at selected electrodes of interest, based on maxima of a particular component in grand mean ERPs and previous research [e.g., (34, 61, 62)]: P100 (O1/O2), N170 (P7/P8, P9/P10, PO9/PO10), P200 (O1/O2, P9/P10, PO9/PO10), N250 (P7/P8, P9/P10, PO9/PO10), and LPC (C3/C4, P3/P4, Cz, and Pz).

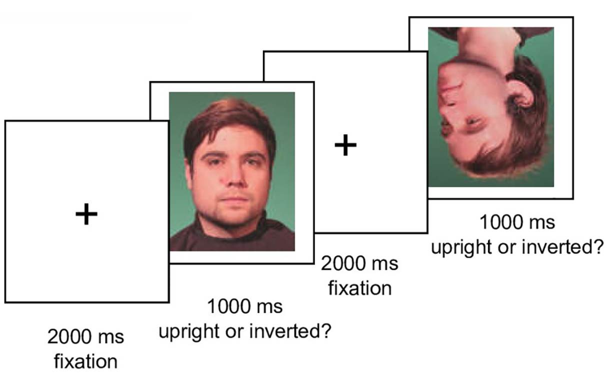

FIGURE 2 | Schematic trial sequence of the experiment. Illustration of two trials with an upright and an inverted male face in the test phase.

Power Analysis

A priori, a power analysis was computed using G-Power 3.1.9.2 (63), with repeated measures ANOVA (within-between design), a moderate effect of f= 0.25 between BDD patients and controls, a power of 0.80 and a correlation among the repeatedly measured dimensions of r = 0.5 (64), resulting in a total sample size of 24. Hence, including a supposed dropout rate of 25% in BDD studies [e.g., (65)], at least a total of 32 participants had to be recruited for this study.

Statistical Analysis

For behavioral analyses, response times (RTs) were analyzed for correct responses only. Error of omissions (no key press) and responses < 200 ms were excluded from statistical analyses. Response accuracy (% correct) and mean correct RTs were computed for each condition and both groups. Analyses of variance (ANOVAs) were performed, with epsilon corrections for heterogeneity of covariances (66) where appropriate. For behavioral analyses, we performed ANOVAs with repeated measurements on face type (own vs. others), orientation (upright vs. inverted) as within-subject factors, and group (BDD vs. HC) as between-subjects factor. For ERP analyses, we performed ANOVAs with repeated measurements on face type (own vs. others), orientation (upright vs. inverted), expression (neutral vs. smiling), hemisphere (left vs. right; not for LPC), site (electrodes, depending on ERP component) as within-subject factors, and group (BDD vs. HC) as between-subjects factor. To further investigate significant group effects or interactions involving group, we subsequently performed separate ANOVAs for both groups. We included the factor expression because recent research provided evidence for biases in emotional face recognition in BDD [e.g., (32, 59)].

In addition, we investigated in ***post hoc*** Bayesian analysis for both behavioral and ERP data, to test evidence for null results. To estimate support for null hypothesis, Bayes factors for ANOVA designs were computed (67) using the statistical software JASP [JASP, 2019; (68, 69)]. For the interpretation of the Bayesian factors, we followed the cutoff values of 0.3 and 3 proposed by Jeffreys, with values between 0.3 and 3 indicating there is no sufficient empirical evidence for the absence of the observed effects (70). Bayesian factors > 3.0 indicate that the confirmation of null hypothesis has a probability of more than three times higher than the alternative hypothesis.

RESULTS

Table 1 summarizes demographic and psychometric data. All participants were unmedicated. BDD and healthy controls did not differ in mean age or educational level. BDD participants were preoccupied with at least one perceived facial defect. Seven patients were additionally preoccupied with perceived bodily defects.

TABLE 1 | Sample characteristics by group for demographic, body dysmorphic disorder (BDD)–related and symptom measures.

	Body Dysmorphic Disorder (BDD)	Healthy Controls (HC)	Stats (*t*)	*p*-value
N	16	16		
Gender (F/M)	11/5	11/5		
Age, mean (SD)	26.19 (8.06)	26.13 (8.23)	0.02	0.983
Age range (min, max)	(20, 54)	(20, 55)	`	
Highest School Diploma Completed	9/16	9/16		
Age of onset BDD	16.31 (10.64)			
Comorbidities (n)	Major Depressive Disorder (4) Dysthymia (1) Social Anxiety Disorder (3) Panic Disorder with Agoraphobia (1) Loss of Sexual Desire (1)			
BDD-YBOCS	25.06 (2.98)			
FKS	31.88 (7.72)	7.75 (4.04)	11.08	0.000
BDI-II	17.38 (11.49)	5.56 (4.29)	3.85	0.001
BSI (GSI)	66.19 (10.74)	44.44 (8.25)	6.43	0.000

Means and standard deviations in parentheses.
BDD-YBOCS, Yale-Brown Obsessive-Compulsive Scale Modified for BDD; FKS, Body Dysmorphic Symptoms Inventory; BDI-II, Beck Depression Inventory-II; BSI, Brief Symptom Inventory; GSI, Global Severity Index.

Behavioral Data

Reaction Times

There was a significant interaction between face type and orientation, $F(1,30) = 7.65$, $p = .010$, $\eta_p^2 = .31$, but no significant group effect, $F(1,30) = 2.88$, $p = .10$, $\eta_p^2 = .03$, and no significant group interactions that included either the factors face type or orientation, Fs $(1,30) < 1$. To follow up on the significant interaction of face type and orientation, we performed pairwise comparisons among face type and orientation. Overall, there were significantly longer reaction times for own inverted (mean reaction time = 571 ms, SD = 67 ms) than own upright faces [mean reaction time = 548 ms, SD = 69 ms, $t(31) = 3.13$, $p = .004$]. Reaction times for other inverted (mean reaction time = 558 ms, SD = 68 ms) and other upright faces [mean reaction time = 566 ms, SD = 75 ms) did not significantly differ, $t(31) = 0.88$, $p = .386$]. See **Table 2** and **Figure 3** for reaction times on face type and orientation by group.

For the interaction between face type, orientation and group, the Bayesian analysis revealed a BFexcl= 1.925, indicating that there is no sufficient evidence for the absence of this effect. Statistics of Bayesian analysis for main and interaction effects can be found in **Table S1** (**Supplementary Materials**).

Accuracy

Overall, response accuracy was generally close to ceiling (BDD: M = 0.92, SD = 0.05; HC: M = 0.93, SD = 0.04). There was a significant interaction between face type and orientation, $F(1,30) = 9.76$, $p = .004$, $\eta_p^2 = .38$, but no significant group effect, $F(1,30) = 0.01$, $p = .913$, $\eta_p^2 = 0$, and no significant interactions including the factor group, Fs $(1,30) < 1.8$. To follow up on the significant interaction of face type and orientation, we performed pairwise comparisons among face type and orientation. Overall, response accuracies were higher for own upright (M = 0.94, SD = 0.05) than own inverted faces [M = 0.91, SD = 0.08, $t(31) = 2.16$, $p = .039$], and for other inverted (M = 0.94, SD = 0.06) than other upright faces [M = 0.91, SD = 0.10, $t(31) = 2.63$, $p = .013$]. See **Table 2** for summary of accuracies by group.

For the interaction between face type, orientation and group, the Bayesian analysis revealed a BF_{excl}= 1.013, indicating that there is no sufficient evidence for the absence of this effect.

TABLE 2 | Accuracies in % for correct responses, reaction times in ms, and between-group multiple comparisons per condition in the test phase for face type, and orientation by group.

	Body Dysmorphic Disorder (BDD)		Healthy controls (HC)		Stats *t*	*p*-value	*t*	*p*-value
	RT	Acc	RT	Acc	RT		Acc	
Own Upright Faces	572 (64)	92.4 (5.1)	524 (66)	95.1 (4.6)	-2.06	0.048	0.88	0.386
Own Inverted Faces	586 (72)	92.5 (6.9)	557 (60)	91.1 (0.1)	-1.22	0.232	-0.15	0.882
Other Upright Faces	584 (74)	91.3 (7.9)	547 (74)	91.0 (8.5)	-1.41	0.169	-0.56	0.581
Other Inverted Faces	577 (72)	93.6 (4.9)	539 (61)	95.5 (4.4)	-1.64	0.111	0.59	0.559

Standard deviations (SD) are given in parentheses.
Acc, accuracy; RT, reaction time.

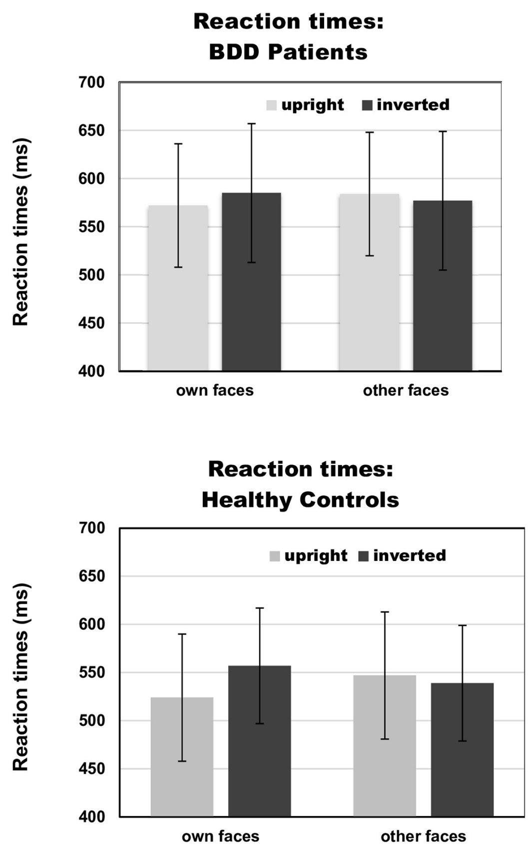

FIGURE 3 | Reaction times on face type (own vs. other) and orientation (upright vs. inverted) by group [body dysmorphic disorder (BDD) patients vs. healthy controls]. Error bars indicate standard deviations.

Statistics of Bayesian analysis for main and interaction effects can be found in **Table S2** (**Supplementary Materials**).

ERPs

P100 Amplitude (80–120 ms)

We found no significant group effect, $F(1,30) = 1.68$, $p = .205$, $\eta_p^2 = .05$, and no significant main effects of face type and orientation, $Fs\ (1,30) < 0.76$. There were no significant group interactions including the factors face type and orientation, $Fs\ (1,30) < 1.84$. Statistics for main and interaction effects can be found in **Table S3** (**Supplementary Materials**).

For the interaction between face type, orientation and group, the Bayesian analysis revealed a BFexcl= 5.260, indicating that there is 5.3 times higher probability for support of the null effect than alternative hypothesis. Statistics of Bayesian analysis for group interaction effects can be found in **Table S4** (**Supplementary Materials**).

N170 Amplitude (120–164 ms)

We found no significant group effect, $F(1,30) = 0.14$, $p = .71$, $\eta_p^2 = .01$. There was a significant main effect of face type, $F(1,30) = 4.25$, $p = .048$, $\eta_p^2 = .12$, and orientation, $F(1,30) = 6.55$, $p = .016$, $\eta_p^2 = .18$, but no significant interaction between face type and orientation, $F(1,30) = 1.46$, $p = .237$, $\eta_p^2 = .05$. Analyses revealed no significant group interactions including either the factors face type and orientation, $Fs\ (1,30) < 2.01$. There was a trend for an interaction between site, face type, orientation, and group, $F(2,60) = 3.31$, $p = .058$, $\eta_p^2 = .10$. Statistics for all main and interaction effects can be found in **Table S5** (**Supplementary Materials**).

To further investigate the interaction trend, we performed separate ANOVAs for both groups. In BDD, a significant main effect of orientation, $F(1,15) = 5.92$, $p = .028$, $\eta_p^2 = .28$, with larger N170 amplitudes for inverted faces and smaller N170 amplitudes for upright faces. A significant main effect of site, $F(2,30) = 16.85$, $p < .001$, $\eta_p^2 = .53$, was further qualified by an interaction with orientation, $F(2,30) = 3.35$, $p = .049$, $\eta_p^2 = .18$, and reflected larger N170 amplitudes for inverted faces at P8, P10 and PO10 electrodes (see **Figure 4**). There was no significant main effect of face type, $F(1,15) = 0.58$, $p = .457$, $\eta_p^2 = .04$, and no significant interaction between face type and orientation, $F(1,15) = 0.02$, $p = .886$, $\eta_p^2 = .00$ (see **Figure 6**). In HC, a significant main effect of face type, $F(1,15) = 8.54$, $p = .010$, $\eta_p^2 = .36$, indicating larger N170 amplitudes for other (relative to own) faces. There was no significant main effect of orientation, $F(1,15) = 1.97$, $p = .180$, $\eta_p^2 = .12$, but a significant interaction between site and orientation, $F(1,15) = 7.18$, $p = .010$, $\eta_p^2 = .32$, indicating larger N170 amplitudes for inverted faces and smaller N170 amplitudes for upright faces at P8 and PO10 electrodes (see **Figure 5**). Analyses revealed no significant interaction between face type and orientation, $F(1,15) = 3.65$, $p = .076$, $\eta_p^2 = .20$ (see **Figure 7**).

For the interaction between face type, orientation and group, the Bayesian analysis revealed a BFexcl= 5.282, indicating that there is 5.3 times higher probability for support of the null effect

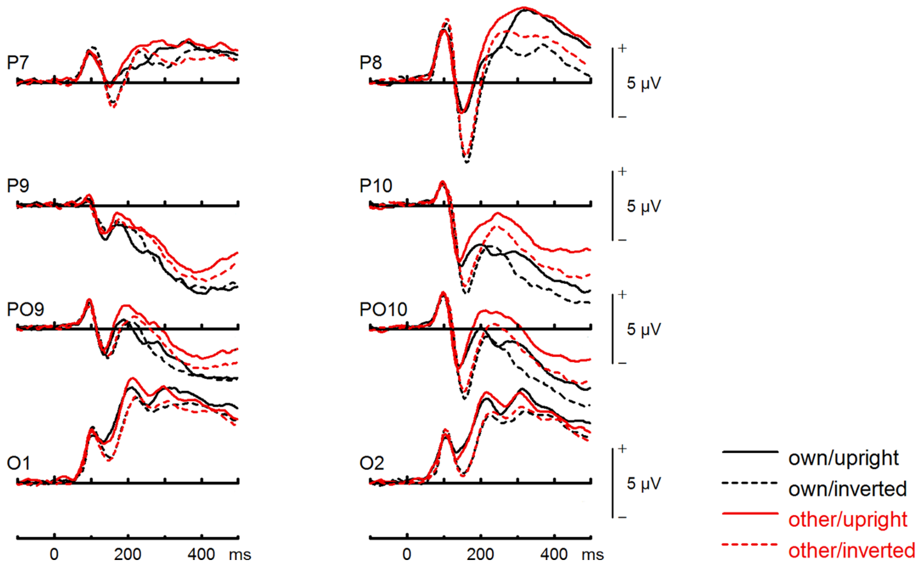

FIGURE 4 | Event-related potentials (ERPs) from the test phase for the interaction face type (own vs. other) by orientation (upright vs. inverted) in body dysmorphic disorder (BDD) patients. At occipito-temporal electrodes (P7/P8, P9/P10, PO9/PO10, O1/O2) within time intervals for P100, N170, P200, and N250.

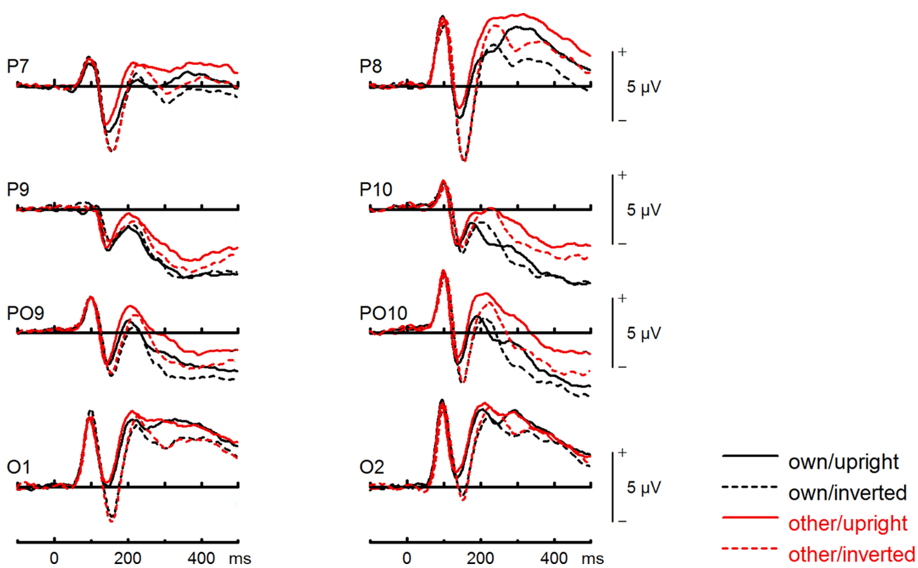

FIGURE 5 | Event-related potentials (ERPs) from the test phase for the interaction face type (own vs. other) by orientation (upright vs. inverted) in healthy controls. At occipito-temporal electrodes (P7/P8, P9/P10, PO9/PO10, O1/O2) within time intervals for P100, N170, P200, and N250.

than alternative hypothesis. Statistics of Bayesian analysis for group interaction effects can be found in **Table S6** (**Supplementary Materials**).

P200 Amplitude (195–225 ms)

We found no significant group effect, $F(1,30) = 0.37$, $p = .55$, $\eta_p^2 = .01$. There was a significant main effect of face type, $F(1,30) = 46.09$, $p < .001$, $\eta_p^2 = .61$, and orientation, $F(1,30) = 19.38$, $p < .001$, $\eta_p^2 = .39$. Analyses revealed a significant interaction between face type and orientation, $F(1,30) = 27.24$, $p < .001$, $\eta_p^2 = .48$. There were no significant group interactions including the factors face type, and orientation, $Fs(1,30) < 1.99$, but a significant interaction between site, face type, orientation, expression, and group, $F(2,60) = 4.66$, $p = .021$, $\eta_p^2 = .13$. Statistics

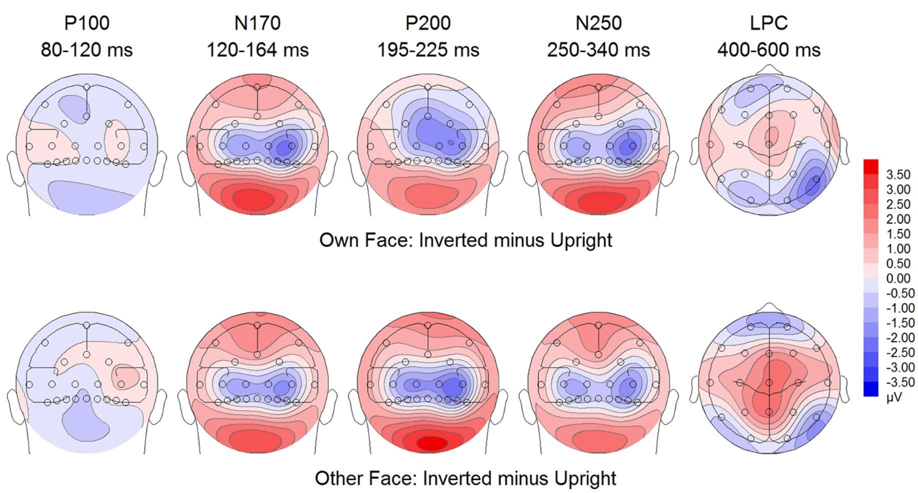

FIGURE 6 | Difference maps from the test phase for the interaction face type (own vs. other) by orientation (upright vs. inverted) in body dysmorphic disorder (BDD) patients. At occipito-temporal electrodes (P7/P8, P9/P10, PO9/PO10, O1/O2) within time intervals for P100, N170, P200, N250 and LPC.

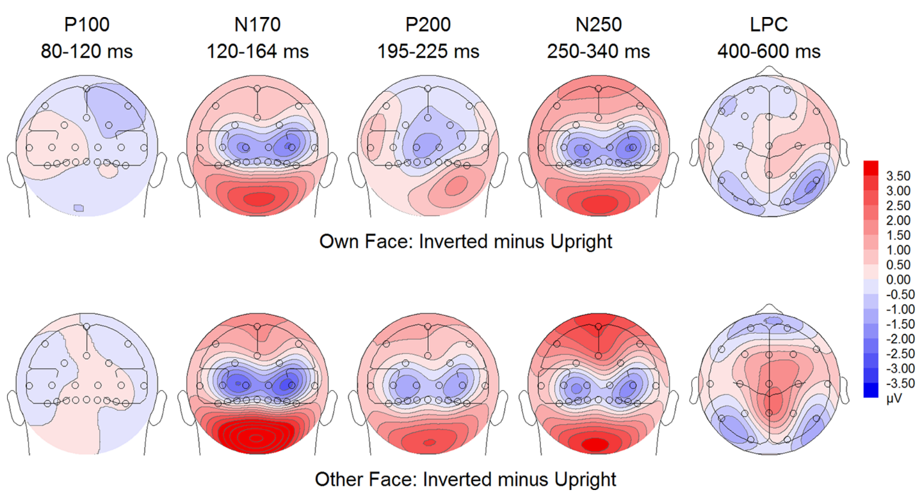

FIGURE 7 | Difference maps from the test phase for the interaction face type (own vs. other) by orientation (upright vs. inverted) in healthy controls. At occipito-temporal electrodes (P7/P8, P9/P10, PO9/PO10, O1/O2) within time intervals for P100, N170, P200, N250 and LPC.

for all main and interaction effects can be found in **Table S7** (**Supplementary Materials**).

To further investigate the significant interaction effect, we performed separate ANOVAs for both groups. In BDD, significant main effects of face type, $F(1,15) = 35.41$, $p = 0$, $\eta_p^2 = .70$, orientation, $F(1,15) = 13.12$, $p = .003$, $\eta_p^2 = .47$. The significant interaction between face type and orientation, *F?A3B2 show $132#?>*(1,15) = 17.61, $p = .001$, $\eta_p^2 = .54$, indicated larger P200 inversion effects to other (relative to own) faces, with larger P200 amplitudes for other upright than other inverted faces (see **Figure 6**). The significant interaction between site and face type, $F(2,30) = 4.35$, $p = .047$, $\eta_p^2 = .23$, indicated larger P200 amplitudes for other (relative to own) faces at P10 and PO10 electrodes (see **Figure 4**). In HC, significant main effects of face type, $F(1,15) = 13.77$, $p = .002$, $\eta_p^2 = .48$, and orientation, $F(1,15) = 7.26$, $p = .017$, $\eta_p^2 = .33$. Analyses revealed a significant interaction between face type and orientation, $F(1,15) = 10.07$, $p = .006$, $\eta_p^2 = .40$, again indicating larger P200 inversion effects to other (relative to own) faces, with larger P200 amplitudes for other upright than other inverted faces (see **Figure 7**). There were significant interactions between site and face type, $F(2,30) = 3.97$, $p = .044$, $\eta_p^2 = .21$, as well as site and orientation, $F(2,30) = 17.50$, $p < .001$, $\eta_p^2 = .54$, with larger (i.e., more positive) P200 amplitudes for other upright than other inverted faces at O1 and O2 electrodes (**Figure 5**).

For the interaction between face type, orientation and group, the Bayesian analysis revealed a BFexcl= 4.484, indicating that there is 4.5 times higher probability for support of the null effect than the alternative hypothesis. Statistics of Bayesian analysis for group interaction effects can be found in **Table S8** (**Supplementary Materials**).

N250 Amplitude (250–340 ms)

We found no significant group effect, $F(1,30) = 0.15$, $p = .70$, $\eta_p^2 = .00$. There was a significant main effect of face type, $F(1,30) = 122.23$, $p < .001$, $\eta_p^2 = .80$, and orientation, $F(1,30) = 66.35$, $p < .001$, $\eta_p^2 = .69$, with larger amplitudes for inverted than upright faces. Analyses revealed no significant interaction between face type and orientation, $F(1,30) = 1.74$, $p = .197$, $\eta_p^2 = .05$, and no significant group interactions including either the factors face type, and orientation, $Fs\ (1,30) < 1.98$. Statistics for all main and interaction effects can be found in **Table S9** (**Supplementary Materials**).

For the interaction between face type, orientation and group, the Bayesian analysis revealed a BF_{excl}= 4.576, indicating that there is 4.6 times higher probability for support of the null effect than the alternative hypothesis. Statistics of Bayesian analysis for group interaction effects can be found in **Table S10** (**Supplementary Materials**).

LPC Amplitude (400–600 ms)

The group effect failed to reach significance, $F(1,30) = 3.78$, $p = .061$, $\eta_p^2 = .11$. There was a significant main effect of face type, $F(1,30) = 135.30$, $p < .001$, $\eta_p^2 = .82$, and orientation, $F(1,30) = 7.04$, $p = .013$, $\eta_p^2 = .19$. Analyses revealed a significant interaction between face type and orientation, $F(1,30) = 12.58$, $p = .001$, $\eta_p^2 = .29$, but no significant group interactions including the factors face type, and orientation, $Fs\ (1,30) < 1.21$. There was a trend for an interaction between site, expression, and group, $F(5,150) = 2.24$, $p = .055$, $\eta_p^2 = .07$. Statistics for all main and interaction effects can be found in **Table S11** (**Supplementary Materials**).

To further investigate the interaction trend, we performed separate ANOVAs for each group. In BDD, analyses revealed significant main effects of face type, $F(1,15) = 105.66$, $p < .001$, $\eta_p^2 = .88$, and orientation, $F(1,15) = 5.99$, $p = .027$, $\eta_p^2 = .29$. There was a significant interaction between face type and orientation, $F(1,15) = 10.75$, p =.005, $\eta_p^2 = .42$, indicating larger LPC inversion effects to other (relative to own) faces, with larger (i.e., more positive) LPC amplitudes for other inverted than other upright faces (see **Figures 6** and **8**). In HC, there was a significant main effect of face type, $F(1,15) = 45.97$, $p < .001$, $\eta_p^2 = .75$, but no significant main effects of orientation, $F(1,15) = 2.14$, $p = .164$, $\eta_p^2 = .12$, and no significant interaction between face type and orientation, $F(1,15) = 3.01$, $p = .103$, $\eta_p^2 = .17$ (see **Figures 7** and **9**).

For the interaction between face type, orientation and group, the Bayesian analysis revealed a BFexcl= 2.447, indicating that there is no sufficient evidence for the absence of this null effect. Statistics of Bayesian analysis for group interaction effects can be found in **Table S12** (**Supplementary Materials**).

DISCUSSION

The present study is the first EEG investigation of the face inversion effect to own and other's faces in BDD by using different ERP correlates of early visual face processing. At some variance with hypotheses and previous EEG findings in BDD (24, 25), results suggest that BDD patients in our observed sample show similarities to healthy controls both at the level of early perceptual processing of the own face (P100, N170, P200), and at the subsequent activation of neural representation of facial identity (N250) and emotional processing (LPC).

In the early P100 component, no evidence for face inversion effects was found in both groups, which is in line with previous EEG research, indicating that the P100 is not sensitive to face inversion (37). In the subsequent N170 component, both groups exhibited the common face inversion effects, with larger N170 amplitudes for inverted than upright faces, possibly reflecting a disruption of configural processing and in consequence a preponderance of featural processing in inverted faces. Contrary to our hypotheses, these effects were not reliably influenced by the factor group. In addition, no specific inversion effects to own (relative to other) faces were found in BDD, relative to controls. In the P200 component, both groups showed larger inversion effects to other (relative to own) faces, with larger P200 amplitudes for other upright than other inverted faces. Larger P200 amplitudes indicate a higher perceived typicality of a face (43, 61, 62, 71), suggesting that other upright faces were perceived as more typical and less distinctive, whereas other inverted faces were perceived as less typical and more distinctive in both groups. This overall pattern appeared to be comparable for both groups. Contrary to hypotheses, we found no smaller P200 amplitudes for own (relative to other) faces in BDD patients, relative to controls. In the N250 component, we found overall face inversion effects with larger N250 amplitudes for inverted than upright faces, which were not influenced by the factor group. Furthermore, analyses revealed no significant group differences in the processing of own (relative to other) faces, suggesting that both groups may have applied similar strategies to encode familiar and unfamiliar faces. This finding is inconsistent with previous behavioral studies that have indicated an effect of familiarity on face recognition in BDD (32, 33). In the LPC, we observed overall more positive amplitudes for other (relative to own) faces. There was also a face inversion effect with increased positivity for inverted version. This effect was more pronounced for other (relative to own) faces in both groups. The finding might reflect more efficient stimulus evaluation of upright faces due to enhanced information transmission and dominant configural processing, in particular in other faces. The *post hoc* Bayesian analysis revealed results that confirm and support the observed null effects for the analyzed ERP components. Similar to EEG findings, the results of behavioral data analyses provided no

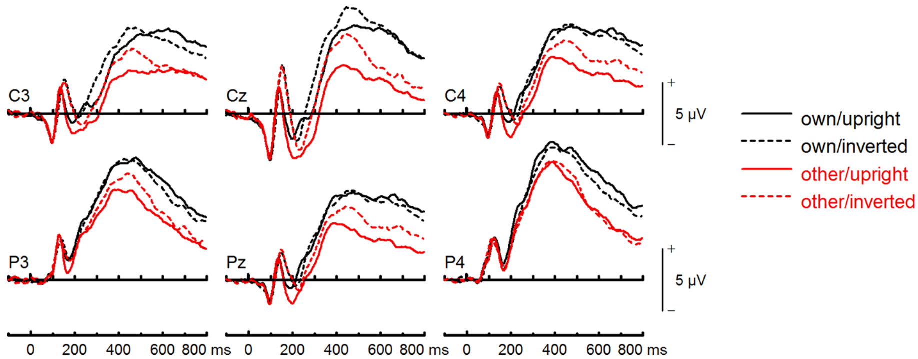

FIGURE 8 | Event-related potentials (ERPs) from the test phase for the interaction face type (own vs. other) by orientation (upright vs. inverted) in body dysmorphic disorder (BDD) patients. At centro-parietal sites (C3/C4, P3/P4, Cz/Pz) within time interval for late positive component (LPC).

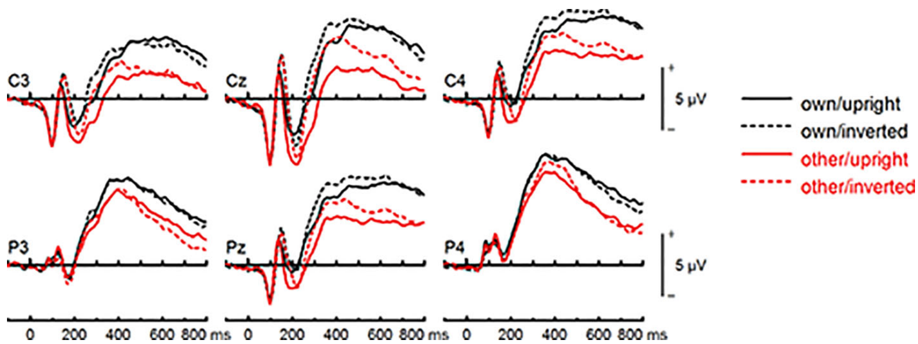

FIGURE 9 | Event-related potentials (ERPs) from the test phase for the interaction face type (own vs. other) by orientation (upright vs. inverted) in healthy controls. At centro-parietal sites (C3/C4, P3/P4, Cz/Pz) within time interval for late positive component (LPC).

evidence for behavioral response abnormalities in BDD. For the whole group, we found a behavioral inversion effect on reaction time to own faces, as well as on accuracy to own and other's faces. However, there was no evidence for group differences and smaller behavioral face inversion effects in BDD.

In general, the face inversion effect is mainly due to deficits in processing of configural and holistic information from inverted faces and occurs primarily at the encoding stage of face processing. Both EEG and behavioral data of the present study suggest that early configural and holistic face processing of the own face may not substantially altered in our observed BDD sample. Our findings are inconsistent with previous fMRI and behavioral studies that provided evidence for a detailed processing of facial features in own and other faces (14–17, 22) and for an abnormal processing of configural and holistic information of own and other faces, objects, scenes and bodies in BDD (23, 30–32, 72, 73). Furthermore, our data are in contrast to previous neuropsychological studies that provided preliminary evidence for smaller P100 and N170 amplitudes as markers of abnormal early structural encoding of faces, and an abnormal spatiotemporal activation of configural and holistic information in BDD (24, 25). These findings suggested an incomplete generation of a whole facial representation, which in turn may contribute to the perceptual distortions in BDD (24).

While abundant evidence exists from behavioral, fMRI and EEG studies for abnormal configural and holistic, and increased detailed processing in BDD, the findings from the current EEG study and previous behavioral studies on face inversion effect are still inconsistent. These inconsistencies might be explained by several methodological differences such as experimental conditions (e.g., presentation time of stimuli). Feusner et al. (30) failed to find a significant smaller inversion effect for short duration stimuli (500ms) but not for long duration stimuli (5,000 ms) in BDD, relative to healthy controls. Similarly, Jeffries et al. (32) provided evidence for a superior recognition of inverted famous faces for long duration stimuli (5,000 ms) in BDD, relative to healthy controls. Monzani et al. (33) examined the face inversion for short duration stimuli (between 200 and 500 ms), and found that BDD patients and healthy controls performed similarly in all aspects of holistic processing and structural encoding tested (33). Mundy and Saduski (31) found enhanced discrimination abilities for inverted faces and bodies, and higher accuracies when discriminating inverted faces and scenes for long duration stimuli (7,000 ms) in individuals with high body dysmorphic concerns, relative to healthy controls. Similar to our EEG study with a presentation time of 1,000 ms, investigations using a short presentation time between 250 and 500 ms (30, 33) failed to find smaller face inversion effects, suggesting that BDD individuals and healthy controls may equally process faces in a global, holistic and configural way when given a brief presentation (30). Thus, long presentation times between 5 and 7 s may allow more time for encoding details (30–32). This might also partly explain the results from previous fMRI and EEG studies, which found abnormal brain activation patterns during encoding of detailed and configural features for longer stimulus presentation times between 3 and 4 s (22, 23, 72), and abnormal early perceptual processing during structural encoding for presentation times of 2s (24, 25).

Furthermore, the inconsistencies in results might also be partly attributed to other methodological differences that generally limit comparisons across studies on visual processing (33) and allow only limited conclusions about abnormal early neurocognitive processes in BDD. For instance, these inconsistencies may also arise from stimulus-related issues and testing conditions. In our study, stimuli were not spatial frequency filtered, while in both EEG studies and in Feusner et al.'s studies (22, 23) facial stimuli were spatial frequency filtered. It has been suggested that different levels of spatial frequencies in stimuli convey different types of information for visual processing (24). This might have had an impact on the results. For instance, in the EEG study by Li et al. (25), BDD individuals demonstrated a hypoactivity in early visual processing regions such as the lateral occipital cortex (linked to the N170 component) for low spatial frequency (i.e., low-detail) faces, and a hyperactivity in the temporal fusiform cortex (linked to the N170 component) for high spatial frequency (i.e., high-detail) houses. However, no abnormalities were found for normal spatial frequency images, regardless of stimulus type (faces or houses). In the fMRI study by Feusner et al. (23), a hypoactivity in the lateral occipital cortex was only found for low spatial frequency own faces in BDD. Furthermore, several previous studies used simultaneous matching tasks of face or house pairs (23–25), while in the current study faces were presented in a sequential task. Long and simultaneous presentations may allow a more comparative feature-based scanning, which is less feasible during short and sequential tasks (33). All these methodological differences raise the question whether the perceptual abnormalities in BDD result from biases for detailed information due to different task conditions or stimulus-related issues, or result from a deficit in configural and holistic processing.

Therefore, further research is necessary to replicate our findings and previous EEG findings (24, 25), and to further investigate early neurocognitive processes in BDD. Overall then, it should be appreciated that the present study investigated ERP correlates of own-face perception in the context of a specific experimental paradigm, and that a comprehensive test of own-face perception across a systematically varied range of experimental conditions was beyond the scope of this single experiment. The current study has several limitations that should be considered when interpreting our findings. First, due to the relatively small sample size in both groups the beta risk was high. For this reason, we computed *post hoc* Bayesian analyses to test evidence for null results. However, a replication of the study and increasing sample size is necessary to overcome this shortcoming. Second, we did not include a clinical control group such as patients with eating disorders that share many clinical features (e.g., body image distortions) with BDD. Therefore, it is not possible to conclude whether the neurocognitive processes tested can be primarily attributed to BDD-specific encoding processes. Third, due to the inclusion of BDD patients with a moderate severity, our results are not generalizable to BDD patients with a higher severity and stronger impairments. Fourth, we did not obtain specific measures to obtain delusional beliefs and insight. Thus, we were not able to determine associations between neural signatures and poor insight in BDD. Fifth, our sample included primarily female BDD patients.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/**Supplementary Material**.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of the Medical Faculty of the Goethe University Frankfurt (GZ 39/11). The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

VR: recruitment and conducting clinical interviews. VR, JMK, HW, SRS, and US: study the design. HW and SRS: programming of experiment, experimental setup. FK: recruitment, stimulus preparation, and EEG acquisition. JMK, VR, HW, and SRS: data collection and data analyses. VR, JMK and SRS: data interpretation. JMK: figures. VR, JMK, HW, US and SRS: literature research and writing of publication.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2020.00302/full#supplementary-material

REFERENCES

1. Taubert J, Apthorp D, Aagten-Murphy D, Alais D. The role of holistic processing in face perception: Evidence from the face inversion effect. *Vision Res* (2011) 51:1273–8. doi: 10.1016/j.visres.2011.04.002
2. Farah MJ, Wilson KD, Drain M, Tanaka JN. What is "special" about face perception? *Psychol Rev* (1998) 105:482–98. doi: 10.1037/0033-295X.105.3.482
3. Wiese H, Wolff N, Steffens MC, Schweinberger SR. How experience shapes memory for faces: An event-related potential study on the own-age bias. *Biol Psychol* (2013) 94(2):369–79. doi: 10.1016/j.biopsycho.2013.07.001
4. Tanaka JW, Farah MJ. Parts and wholes in face recognition. *J Q Exp Psychol* (1993) A46:225–45. doi: 10.1080/14640749308401045
5. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders. DSM-5*. Washington DC: American Psychiatric Publishing (2013). doi: 10.1176/appi.books.9780890425596.744053
6. Phillips KA, McElroy SL, Keck PE, Pope HG, Hudson JI. Body dysmorphic disorder: 30 cases of imagined ugliness. *Am J Psychiatry* (1993) 150:302–8. doi: 10.1176/ajp.150.2.302
7. Phillips KA, Menard W, Pagano ME, Fay C, Stout RL. Delusional versus nondelusional body dysmorphic disorder: clinical features and course of illness. *J Psychiatr Res* (2006) 40:95–104. doi: 10.1016/j.jpsychires.2005.08.005
8. Gunstad J, Phillips KA. Axis I comorbidity in body dysmorphic disorder. *Compr Psychiatry* (2003) 44:270–6. doi: 10.1016/S0010-440X(03)00088-9
9. Phillips KA, Coles ME, Menard W, Yen S, Fay C, Weisberg RB. Suicidal ideation and suicide attempts in body dysmorphic disorder. *J Clin Psychiatry* (2005) 66:717–25. doi: 10.4088/JCP.v66n0607
10. Phillips KA, Menard W, Fay C, Pagano ME. Psychosocial functioning and quality of life in body dysmorphic disorder. *Compr Psychiatry* (2005) 46:254–60. doi: 10.1016/j.comppsych.2004.10.004
11. Feusner JD, Neziroglu F, Wilhelm S, Mancusi L, Bohon C. What causes BDD: research findings and a proposed model. *Psychiatr Ann* (2010) 40:349–55. doi: 10.3928/00485713-20100701-08
12. Veale D, Neziroglu F. *Body dysmorphic disorder. A treatment manual*. Chichester: Wiley (2010).
13. Wilhelm S, Phillips KA, Steketee G. *Cognitive-Behavioral Therapy for Body Dysmorphic Disorder. A Treatment Manual*. New York: Guilford Press (2013).
14. Thomas CS, Goldberg DP. Appearance, body image and distress in facial dysmorphophobia. *Acta Psychiatr Scand* (1995) 92:231–6. doi: 10.1111/j.1600-0447.1995.tb09574.x
15. Yaryura-Tobias JA, Neziroglu F, Chang R, Lee S, Pinto A, Donohue L. Computerized perceptual analysis of patients with body dysmorphic disorder. *CNS Spectr* (2002) 7:444–60. doi: 10.1017/S1092852900017958
16. Lambrou C, Veale D, Wilson G. The role of aesthetic sensitivity in body dysmorphic disorder. *J Abnorm Psychol* (2011) 120:443–53. doi: 10.1037/a0022300
17. Stangier U, Adam-Schwebe S, Müller T, Wolter M. Discrimination of facial appearance related stimuli in body dysmorphic disorder. *J Abnorm Psychol* (2008) 117:435–43. doi: 10.1037/0021-843X.117.2.435
18. Buhlmann U, Rupf L, Gleiss MJL, Zschenderlein K, Kathmann N. Seeing "changes" that aren't there: Facial and object discrimination in body dysmorphic disorder. *Compr Psychiatry* (2014) 55:468–74. doi: 10.1016/j.comppsych.2013.09.011
19. Reese HE, McNally RJ, Wilhelm S. Facial asymmetry detection in patients with body dysmorphic disorder. *Behav Res Ther* (2010) 48:936–40. doi: 10.1016/j.brat.2010.05.021
20. Grocholewski A, Kliem S, Heinrichs N. Selective attention to imagined facial ugliness is specific to body dysmorphic disorder. *Body Image* (2012) 9(2):261–9. doi: 10.1016/j.bodyim.2012.01.002
21. Kollei I, Horndasch S, Erim Y, Martin A. Visual selective attention in body dysmorphic disorder, bulimia nervosa and healthy controls. *J Psychosom Res* (2017) 92:26–33. doi: 10.1016/j.jpsychores.2016.11.008
22. Feusner JD, Townsend J, Bystritsky A, Bookheimer S. Visual information processing of faces in body dysmorphic disorder. *Arch Gen Psychiatry* (2007) 64:1417–26. doi: 10.1001/archpsyc.64.12.1417
23. Feusner JD, Moody T, Hembacher E, Townsend J, McKinley M, Moller H, et al. Abnormalities of visual processing and frontostriatal systems in body dysmorphic disorder. *Arch Gen Psychiatry* (2010) 67:197–205. doi: 10.1001/archgenpsychiatry.2009.190
24. Li W, Lai TM, Loo SK, Strober M, Mohammad-Rezazadeh I, Khalsa I, et al. Aberrant early visual neural activity and brain-behavior relationships in anorexia nervosa and body dysmorphic disorder. *Front Hum Neurosci* (2015) 9:301. doi: 10.3389/fnhum.2015.00301
25. Li W, Lai TM, Bohon C, Loo SK, McCurdy D, Strober M, et al. Anorexia nervosa and body dysmorphic disorder are associated with abnormalities in processing visual information. *Psychol Med* (2015) 45:2111–22. doi: 10.1017/S0033291715000045
26. Yin RK. Looking at upside-down faces. *J Exp Psychol* (1969) 81:141–5. doi: 10.1037/h0027474
27. Kanwisher N, Yovel G. The fusiform face area: a cortical region specialized for the perception of faces. *Philos Trans R Soc B* (2006) 361:2109–28. doi: 10.1098/rstb.2006.1934
28. Pitcher D, Duchaine B, Walsh V, Yovel G, Kanwisher N. The role of lateral occipital face and object areas in the face inversion effect". *Neuropsychologia* (2011) 49:3448–53. doi: 10.1016/j.neuropsychologia.2011.08.020
29. Freire A, Lee K, Symons LA. The face-inversion effect as a deficit in the encoding of configural information: Direct evidence. *Perception* (2000) 29:159–70. doi: 10.1068/p3012
30. Feusner JD, Moller H, Altstein L, Sugar C, Bookheimer S, Yoon J, et al. Inverted face processing in body dysmorphic disorder. *J Psychiatr Res* (2010) 44:1088–94. doi: 10.1016/j.jpsychires.2010.03.015
31. Mundy ME, Sadusky A. Abnormalities in visual processing amongst students with body image concerns. *Adv Cognit Psychol* (2014) 10:39–48. doi: 10.5709/2Facp-0155-4
32. Jeffries K, Laws KR, Fineberg NA. Superior face recognition in body dysmorphic disorder. *J Obsessive Compuls Relat Disord* (2012) 1:175–9. doi: 10.1016/j.jocrd.2012.03.002
33. Monzani B, Krebs G, Anson M, Veale D, Mataix-Cols D. Holistic versus detailed visual processing in body dysmorphic disorder: Testing the inversion, composite and global precedence effects. *Psychiatry Res* (2013) 210:994–9. doi: 10.1016/j.psychres.2013.08.009
34. Wiese H, Stahl J, Schweinberger SR. Configural processing of other race faces is delayed but not decreased. *Biol Psychol* (2009) 81:103–9. doi: 10.1016/j.biopsycho.2009.03.002
35. Schweinberger SR. Neurophysiological correlates of face recognition. In: Calder AJ, Rhodes G, Johnson MH, Haxby JV, editors. *Oxford handbook of face perception*. Oxford, New York: Oxford University Press (2011). p. 345–66.
36. Luck SJ. *An Introduction to the Event-Related Potentials Technique*. (Cambridge: MIT Press) (2005).
37. Herrmann MJ, Ehlis AC, Ellgring H, Fallgatter AJ. Early stages (P100) of face perception in humans as measured with event-related potentials (ERPs). *J Neural Transm* (2005) 112:1073–81. doi: 10.1007/s00702-004-0250-8
38. Eimer M. Effects of face inversion on the structural encoding and recognition of faces - evidence from event-related brain potentials. *Cognit Brain Res* (2000) 10:145–58. doi: 10.1016/S0926-6410(00)00038-0
39. Rossion B, Gauthier I, Tarr MJ, Despland P, Bruyer R, Linotte S, et al. The N170 occipito-temporal component is delayed and enhanced to inverted faces but not to inverted objects: an electrophysiological account of face-specific

processes in the human brain. *Neuroreport* (2000) 11:69–74. doi: 10.1097/00001756-200001170-00014
40. Estudillo AJ, Kaufmann JM, Bindemann M, Schweinberger SR. Multisensory stimulation modulates perceptual and post perceptual face representations: Evidence from event-related potentials. *Eur J Neurosci* (2018) 48:2259–71. doi: 10.1111/ejn.14112
41. Keyes H, Brady N, Reilly RB, Fox JJ. My face or yours? Event-related potential correlates of self-face processing. *Brain Cognit* (2010) 72:244–54. doi: 10.1016/j.bandc.2009.09.006
42. Kaufmann JM, Schweinberger SR. The faces you remember: caricaturing shape facilitates brain processes reflecting the acquisition of new face representations. *Biol Psychol* (2012) 89:21–33. doi: 10.1016/j.biopsycho.2011.08.011
43. Zheng X, Mondloch CJ, Segalowitz SJ. The timing of individual face recognition in the brain. *Neuropsychologia* (2012) 50:1451–61. doi: 10.1016/j.neuropsychologia.2012.02.030
44. Kaufmann JM, Schweinberger SR, Burton AM. N250 ERP correlates of the acquisition of face representations across different images. *J Cognit Neurosci* (2009) 21:625–41. doi: 10.1162/jocn.2009.21080
45. Schweinberger SR, Huddy V, Burton AM. N250r: A face-selective brain response to stimulus repetitions. *NeuroReport* (2004) 15:1501–5. doi: 10.1097/01.wnr.0000131675.00319.42
46. Werheid K, Schacht A, Sommer W. Facial attractiveness modulates early and late event-related brain potentials. *Biol Psychol* (2007) 76:100–8. doi: 10.1016/j.biopsycho.2007.06.008
47. Wittchen HU, Zaudig M, Fydrich T. *Strukturiertes Klinisches Interview für DSM IV*. Göttingen: Hogrefe (1997).
48. First MB, Spitzer RL, Gibbon M, Williams JBW. *Structured Clinical Interview for DSM-IV Axis I Disorders - Patient Edition*. New York: Biometrics Research Department (1995).
49. Stangier U, Hungerbühler R, Meyer A, Wolter M. Diagnostische Erfassung der Körperdysmorphen Störung: Eine Pilotstudie. *Nervenarzt* (2000) 71:876–84. doi: 10.1007/s001150050678
50. Phillips KA. Body dysmorphic disorder diagnostic module (BDDDM). In: Phillips KA, editor. *The Broken Mirror. Understanding and Treating Body Dysmorphic Disorder*. New York, Oxford: Oxford University Press (1996). p. 323.
51. Phillips KA, Hollander E, Rasmussen SA, Aronowitz BR, DeCaria C, Goodman WK. A severity rating scale for body dysmorphic disorder: Development, reliability and validity of a modified version of the Yale-Brown Obsessive-Compulsive Scale. *Psychopharmacol Bull* (1997) 33:17–22.
52. Phillips KA, Hart AS, Menard W. Psychometric evaluation of the Yale-Brown Obsessive-Compulsive Scale modified for body dysmorphic disorder (BDD-YBOCS). *J Obsessive Compuls Relat Disord* (2014) 3:205–8. doi: 10.1016/j.jocrd.2014.04.004
53. Buhlmann U, Wilhelm S, Glaesmer H, Brähler E, Rief W. Fragebogen körperdysmorpher Symptome (FKS): Ein Screening-Instrument. *Verhaltenstherapie* (2009) 19:237–42. doi: 10.1159/000246278
54. Hautzinger M, Bailer M, Worall H, Keller F. *Beck Depressions Inventar (BDI-II) [Beck Depression Inventory (BDI)]*. Göttingen: Hogrefe (2000).
55. Beck AT, Steer RA. *Manual for the revised Beck Depression Inventory*. San Antonio, TX: Psychological Corporation (1987).
56. Franke GH. *BSI. Brief Symptom Inventory von L.R. Derogatis (Kurzform der SCL-90-R): Deutsche Version, Manual*. Göttingen: Beltz (2000).
57. Derogatis LR, Melisaratos N. The Brief Symptom Inventory: an introductory report. *Psychol Med* (1983) 13:595–605. doi: 10.1017/S0033291700048017
58. Oldfield RC. The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychologia* (1971) 9:97–113. doi: 10.1016/0028-3932(71)90067-4
59. Buhlmann U, Etcoff NL, Wilhelm S. Emotion recognition bias for contempt and anger in body dysmorphic disorder. *J Psychiatr Res* (2006) 40:105–11. doi: 10.1016/j.jpsychires.2005.03.006
60. Berg P, Scherg M. A multiple source approach to the correction of eye artifacts. *Electroencephalogr Clin Neurophysiol* (1994) 90:229–41. doi: 10.1016/0013-4694(94)90094-9
61. Schulz C, Kaufmann JM, Kurt A, Schweinberger SR. Faces forming traces: neurophysiological correlates of learning naturally distinctive and caricatured faces. *NeuroImage* (2012) 63:491–500. doi: 10.1016/j.neuroimage.2012.06.080
62. Schulz C, Kaufmann JM, Walther L, Schweinberger SR. Effects of anticaricaturing vs. caricaturing elucidate the role of shape for face learning. *Neuropsychologia* (2012) 50:2426–34. doi: 10.1016/j.neuropsychologia.2012.06.013
63. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Meth* (2007) 39:175–91. doi: 10.3758/BF03193146
64. Ray JW, Shadish WR. How interchangeable are different estimators of effect size? *J Consult Clin Psychol* (1996) 64:1316–25. doi: 10.1037/0022-006X.64.6.1316
65. Harrison A, Fernandez de la Cruz L, Enander J, Radua J, Mataix-Cols D. Cognitive-behavioral therapy for body dysmorphic disorder: A systematic review and meta-analysis of randomized controlled trials. *Clin Psychol Rev* (2016) 48:43–51. doi: 10.1016/j.cpr.2016.05.007
66. Huynh H, Feldt LS. Estimation of the box correction for degrees of freedom from sample data in randomized block and split-plot designs. *J Educ Behav Stat* (1976) 1:69–82. doi: 10.3102/10769986001001069
67. Rouder JN, Morey RD, Speckman PL, Province JM. Default Bayes Factors for ANOVA Designs. *J Math Psychol* (2012) 56:356–74. doi: 10.1016/j.jmp.2012.08.001
68. JASP Team. (2019). JASP (Version 0.11.1) [Computer software].
69. Morey RD, Rouder JN. (2015). BayesFactor (Version 0.9.10-2) [Computer software].
70. Jeffreys H. *The Theory of Probability*. *Third Edition* (Oxford: Oxford University Press) (1998).
71. Kaufmann JR, Schulz C, Schweinberger SR. High and low performers differ in the use of shape information for face recognition. *Neurospychologia* (2013) 51:1310–9. doi: 10.1016/j.neuropsychologia.2013.03.015
72. Feusner JD, Hembacher E, Moller H, Moody TD. Abnormalities of object visual processing in body dysmorphic disorder. *Psychol Med* (2011) 41:2385–97. doi: 10.1017/S0033291711000572
73. Kerwin L, Hovav S, Hellemann G, Feusner JD. Impairment in local and global processing and set shifting in body dysmorphic disorder. *J Psychiatr Res* (2014) 57:41–50. doi: 10.1016/j.jpsychires.2014.06.003

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