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## Article

# Does Identifying with Another Face Alter Body Image Disturbance in Women with an Eating Disorder? An Enfacement Illusion Study

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**Abstract: Background/Objectives:** Individuals with eating disorders (EDs) experience stronger body illusions than controls, which may indicate abnormalities in multisensory processing underlying misperceptions of one's body. These illusions can also temporarily reduce body image disturbance in EDs. Since the face is often a key component of identity and social functioning, and emerging evidence suggests distorted self-face perception in EDs, this study examined whether a facial illusion (the enfacement illusion) produces similar effects. **Methods:** White Australian women, 19 with an ED and 24 control participants, completed synchronous and asynchronous facial mimicry tasks to induce the enfacement illusion. Enfacement was assessed via self-report and an objective self-face recognition task, alongside pre- and post-illusion measures of face and body image disturbance (perceived facial attractiveness, adiposity estimation, and head/body dissatisfaction). **Results:** The illusion was successfully induced across both groups. Unexpectedly, ED and control participants were equally susceptible to the illusion, and neither group experienced improvements in face or body image disturbance. Notably, ED participants experienced increased head dissatisfaction following the illusion. **Conclusions:** These findings suggest that the multisensory integration processes underlying self-face perception may remain intact in EDs, unlike the disruptions seen in body perception. However, the limited therapeutic effects of the enfacement illusion highlight how socio-emotional processing biases in EDs, such as heightened self-consciousness and sensitivity to evaluation, may constrain its benefits. These findings offer novel starting points for future research to consider how socio-emotional processes shape self-face perception in EDs, not just sensory integration.

**Keywords:** eating disorder; self-perception; face perception; body image disturbance; enfacement illusion; embodiment illusion; multisensory integration

## Introduction

Body image disturbance is a central feature of eating disorders (EDs), particularly anorexia nervosa (AN) and bulimia nervosa (BN) [1] and is also common in binge eating disorder (BED) and other specified feeding or eating disorders (OSFED) [2]. Body image disturbance plays a key role in the onset, maintenance, and poor treatment outcomes of EDs [2,3]. While cognitive-affective components, such as body dissatisfaction and drive for thinness, have been extensively studied, EDs are also characterised by perceptual distortions, such as body size and shape misestimation [4,5]. Despite being common, persistent, and linked to poorer outcomes [4,6,7], these perceptual disturbances remain comparatively less understood and are neglected in conventional treatments [8,9]. The mechanisms underlying these distortions, and more broadly how the bodily self is mentally represented in EDs, remain unclear.

Recent neuroscientific advances demonstrate that bodily self-representations are not static but rather dynamic, continuously shaped and updated through multisensory integration—the dynamic process by which the brain combines sensory information across multiple modalities (e.g., vision, touch, interoception, proprioception) [10,11]. Embodiment illusions offer compelling experimental support for this dynamic nature of body representation. *These paradigms* exploit multisensory integration processes to temporarily alter, for example, the sense of bodily ownership by inducing

the illusion of ownership over artificial body parts or entire bodies [12]. In the classic rubber hand illusion, participants observe a rubber hand being stroked while feeling synchronised touches on their unseen hand, with such congruent visuo-tactile cues creating an illusory sense of owning the rubber hand [13]. These principles have been extended to the entire body through full-body illusions via virtual reality [14].

Embodiment illusions have advanced understanding of distorted body perception in EDs and also show therapeutic promise (for review, see [15]). AN and mixed ED samples consistently demonstrate heightened susceptibility to the rubber hand illusion, in particular, compared to controls [16–18]. One full-body illusion study showed similar findings when stimulating the abdomen [19]. These results provide evidence of heightened bodily plasticity in EDs and support the role of disrupted multisensory integration processes underlying distorted body perception in these populations. Therapeutically, embodying another body or body part that differs from one's actual or perceived physical appearance, such as a positively evaluated or "healthy" model, has been shown to recalibrate distorted body perception and subsequently improve ED symptoms [19,20]. Improvements appear most pronounced in ED populations compared to controls [19,21], presumably because greater negative self-evaluations at baseline allow more room for improvement.

Importantly, however, while embodiment illusion research has traditionally focused on the body, the face represents a central yet understudied component of self-representation in EDs. Self-face perception is typically central to identity [22] and one's face plays an important role in social cognition and emotional communication [23,24]. EDs are associated with disturbances in identity [25,26] and socio-cognitive functioning domains [27]. Moreover, social media usage is a documented ED risk factor among young women [28] and has intensified facial appearance concerns and dissatisfaction among users [29,30]. Limited research suggests that women with or at high risk of EDs exhibit deficits in self-face perception, including poorer self-face recognition accuracy [31,32] and facial image disturbances (e.g., facial dissatisfaction, lower perceived attractiveness, and higher adiposity [facial weight] estimation) [32,33], mirroring traditional body image disturbances. Despite such concerns, ED research and treatments overwhelmingly focus on body shape and weight (e.g., [8]). Neglecting self-face perception may limit our understanding of image disturbance in EDs and its full clinical impact.

Importantly, self-face representations, like bodily representations, are malleable, and the enfacement illusion [34,35] provides a powerful tool for investigating such phenomena. Synchronous visuo-motor or visuo-tactile stimulation can induce self-other merging, whereby the features of an external face are incorporated into one's self-representation [22]. While the enfacement illusion has been increasingly used to study the perceptual plasticity of self-face representation, its application in ED populations is critically limited (for discussion, see [36]). A recent community-based study by Portingale et al. [37] of White and Asian women ( $N = 226$ ,  $n = 102$  high ED-risk via the Eating Attitudes Test-26 [EAT-26 [38]]), found no differences in enfacement illusion susceptibility between high and low ED-risk groups. Unexpected post-enfacement illusion effects were also observed: high-risk participants showed increased body and head dissatisfaction, whereas low-risk participants showed improvements. These findings contrast with prior embodiment illusion research indicating that clinical ED participants show greater illusion susceptibility and might also derive greater therapeutic benefit than controls [17,19]. However, community samples may mask clinically meaningful effects. Community-based embodiment illusion studies have reported null effects of non-clinical ED symptomatology on susceptibility [39] and negative changes in body image post-embodiment that correlated with the degree of (non-clinical) ED symptomatology [20].

The present study aimed to extend prior work by examining the enfacement illusion in women with an ED compared to controls. Our objectives were twofold: (1) to assess whether individuals with an ED show heightened susceptibility to the enfacement illusion compared to controls; and (2) to determine whether experiencing the illusion improves face and/or body image disturbance, particularly in those with an ED.

We hypothesised that ED participants would be more susceptible to the enfacement illusion than controls (H1), and that improvements in face and/or body image disturbance would occur after experiencing the enfacement illusion task (H2), particularly for ED participants compared to controls (H3).

## Materials and Methods

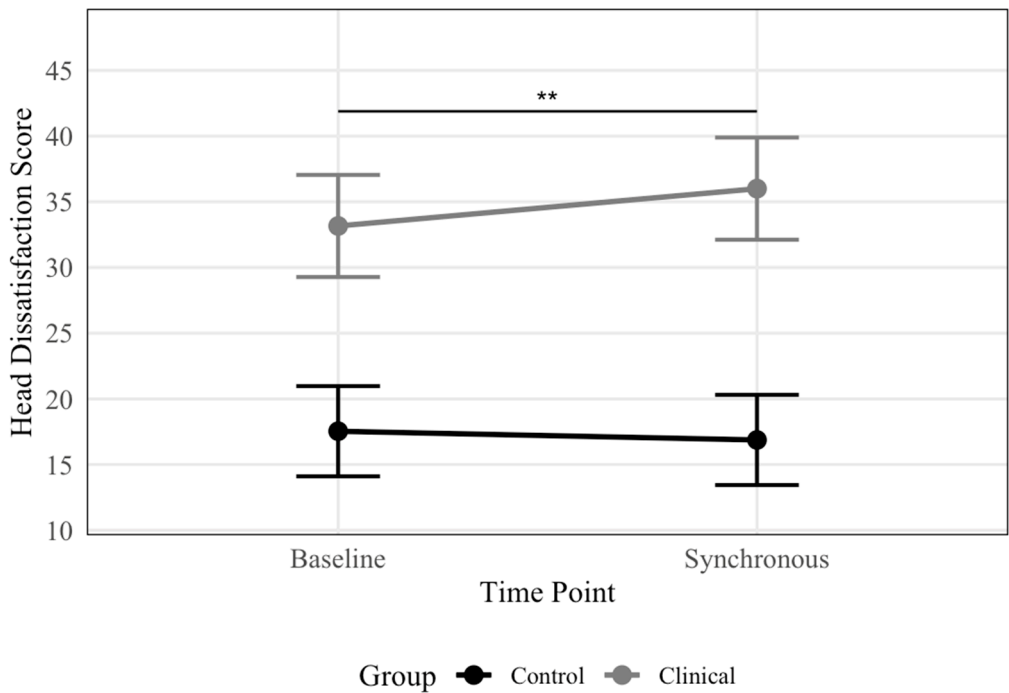
Ethical approval was granted by a Melbourne university [masked for review]. All participants provided informed consent and were compensated for their time with university course credit or e-gift vouchers. The study followed a published protocol [40] with minor deviations in the clinical sample. The study’s design, hypotheses and analysis plan were pre-registered on the Open Science Framework [masked for review].

Participants

Nineteen individuals with an ED and 24 control individuals were recruited for the study. ED and control participants were recruited from an Australian university’s participant pool, university noticeboards, social media, and word-of-mouth referrals. ED participants were also recruited through ED-related organisations and private practices. Inclusion criteria required participants to be cisgender women, White, ≥18 years old, proficient in English, and without physical conditions preventing task performance.

ED participants were initially identified based on a self-reported current ED diagnosis and symptom levels indicative of high ED risk using the EAT-26 [38] and were then required to meet DSM-5 diagnostic criteria for an ED [41] which was verified using the Eating Disorder Examination (EDE) v17.0D [42]. Participants with comorbid psychiatric conditions were not excluded as this would not have represented a typical ED sample. Control participants were required to self-report no history of an ED and minimal disordered eating symptoms using the EAT-26 [38].

ED diagnoses included AN restricting (*n* = 6), AN binge-purge (*n* = 2), BN (*n* = 2), and OSFED (*n* = 9). OSFED subtypes comprised atypical AN (*n* = 2), low frequency/limited duration BED (*n* = 1), low frequency/limited duration BN (*n* = 4), and purging disorder (*n* = 2). The mean duration of the ED diagnosis was 5.31 years (*SD* = 8.13), with an average age of onset of 22.16 years (*SD* = 9.72). Participants were typically young adults. Average body mass index (BMI) was considered healthy across ED and control individuals (six ED individuals and four control individuals were considered overweight/obese). ED participants were significantly older and more educated than controls. For complete participant demographic and clinical information, see Table 1.



**Figure 2.** Head Dissatisfaction Scores by Condition and Group. Note. Line plot displaying estimated marginal means of head dissatisfaction scores, presented by condition and group. Significantly greater head dissatisfaction was observed following the synchronous condition compared to baseline for the ED group, with no significant difference between conditions for the control group. Error bars represent 95% confidence intervals, with significance brackets showing where differences occur. \*\* *p* < .01.



Stimuli

Stimulation Videos

Six young adult White female models were selected based on third-party ratings from a demographically matched sample, ensuring average levels of attractiveness, adiposity, and likability, as well as emotional neutrality—attributes influencing enfacement (e.g., [43,44]). Videos were recorded of each model to develop the facial mimicry task stimuli used for multisensory (visuo-motor) stimulation (Figure 1b). Each video featured a front-facing model alternating between a neutral expression and an exaggerated visible-tooth smile every 10 seconds for 150 seconds—slightly longer than the standard 120-second duration [35] to maximise the likelihood of enfacement.

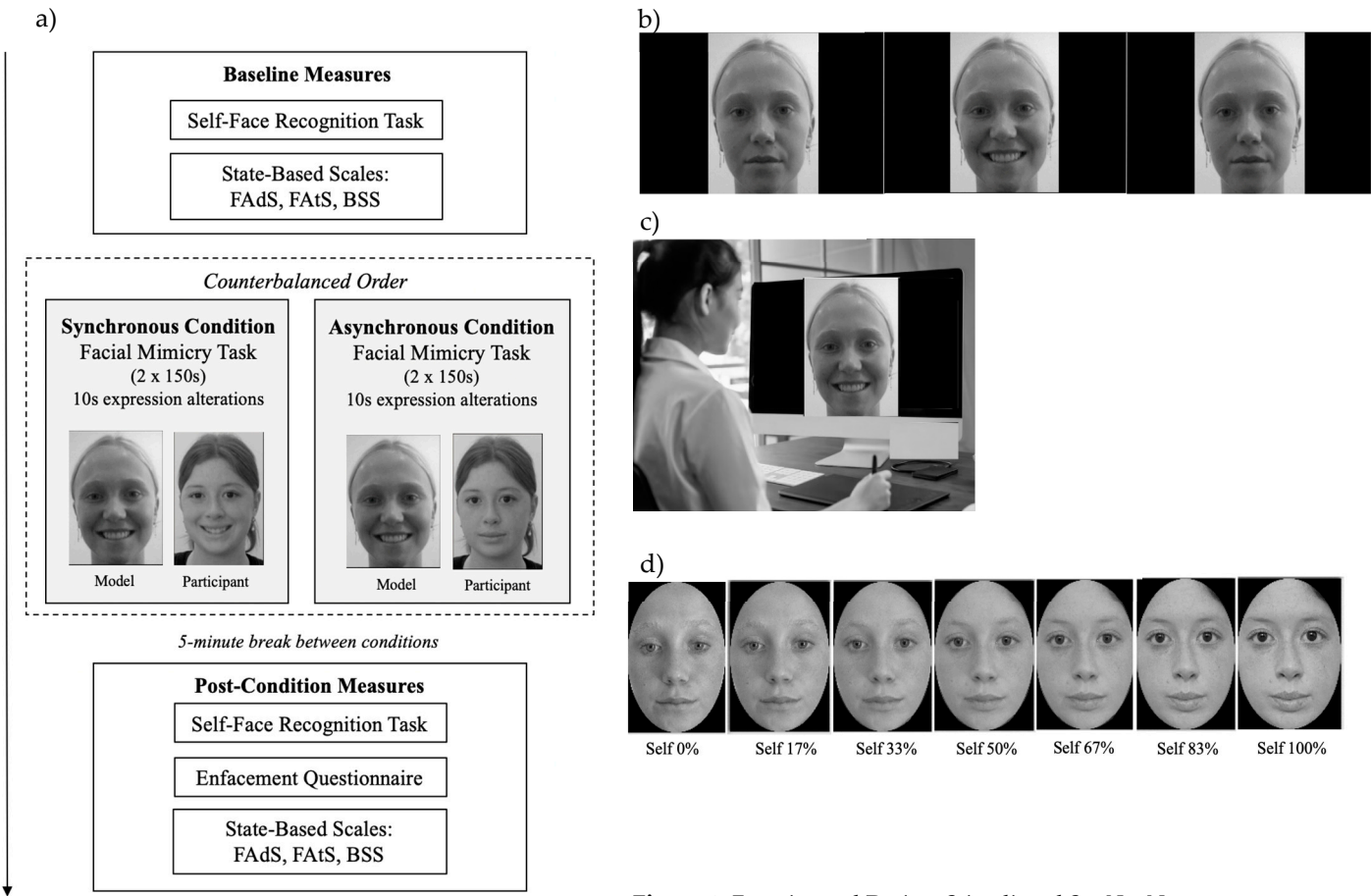


Figure 1. Experimental Design, Stimuli, and Set-Up. Note.

(a) Graphical depiction of the experimental procedure; (b) stimulation video depicting a model alternating between neutral and smiling expressions at 10s intervals, over each 150 second trial (section of the video depicted for illustrative purposes); (c) participant completes the synchronous condition (performing the corresponding facial expression to the model); (d) morphing video sequence—used for the self-face recognition task—which involved images transitioning from 0% self (100% model) to 100% self (0% model) (depicted in standardised 17% increments for illustrative purposes). Measures: FAdS = Facial Adiposity Scale; FAtS = Facial Attractiveness Scale; BSS = Body Satisfaction Scale.

Morph Videos

For the self-face recognition task (Figure 1d), morphing videos were custom-generated for each participant using a front-view, neutral-expression photograph of their face. Images were mirror-transposed, converted to grey-scale, and circular-cropped to remove non-facial features (background, ears, hair) [35] via PhotoScape X (Version 4). Model images underwent the same processing. Each participant's face was morphed with their model's face (the same identity used in the stimulation video) in 1% increments, creating a 100-frame video transitioning from 0% to 100% self-face over 100 seconds using Abrosoft FantaMorph [45].

Measures

Demographic and Clinical Information

Self-report demographic information included age, height, weight (to calculate BMI), primary language, sexual orientation, marital status, and employment status. ED history (current/lifetime diagnosis, age of onset, illness duration) was also collected.

Formal DSM-5 ED diagnoses were verified via the EDE v17.0D [42]. Interviews were conducted by a registered clinical psychologist or trained postgraduate researchers and were double-screened for reliability. The EDE also provides a global severity score based on four subscales (dietary restraint, eating concern, weight concern, and shape concern). The EAT-26 [38], a 26-item measure of ED symptoms, was used to pre-screen the ED group (a validated cut-off score  $\geq 20$  denoting high ED risk) and determine control group eligibility (a score between 0 and 5 indicating minimal disordered eating). In the present study, internal consistency for the EAT-26 was excellent ( $\alpha = .968$ ).

### *State-Based Outcome Measures*

**Subjective Enfacement.** The 8-item Enfacement Questionnaire (EQ) [46] assesses subjective enfacement on a 7-point scale (-3 = strongly disagree, 3 = strongly agree). The questionnaire contains three subcomponents: *self-identification* (4 items; feeling that the model's face was their own), *similarity* (2 items; perceived resemblance), and *affect* (2 items; perceived attractiveness/trustworthiness of the model). Subcomponent scores were calculated by averaging relevant items (range: -3 to 3), and a total score was computed as the mean of the three subcomponents (range: -3 to 3). Higher scores indicate greater subjective enfacement. In the current study, internal consistency was good across conditions for the total score ( $\alpha = .836-.844$ ).

**Objective Enfacement.** In the self-face recognition task [35], participants viewed a morphing video (0% self to 100% self) and were instructed to press the spacebar when the image appeared more like themselves. Stopping times were converted to the % of frames judged as "self". Earlier stopping times (lower % of self) following stimulation indicate enfacement, reflecting increased acceptance of the model's features as their own.

**Facial Attractiveness and Adiposity.** Participants rated their perceived facial attractiveness and adiposity on separate 7-point scales (0 = very unattractive/underweight, 6 = very attractive/overweight) [47,48]. Higher scores indicate greater perceived facial attractiveness and adiposity.

**Head and Body Dissatisfaction.** The Body Satisfaction Scale (BSS) [49] comprises two validated 7-item sub-scales assessing dissatisfaction with features of the head (head, face, jaw, teeth, nose, mouth, eyes) and body (shoulders, chest, tummy, arms, hands, legs feet) (1 = very satisfied, 7 = very unsatisfied). Scores are summed for each subscale (range: 7–49). Higher scores indicate greater dissatisfaction. In the present study, internal consistency was good-excellent across conditions for both subscales ( $\alpha = .894-.933$ ).

### **Procedure**

Participants were pre-screened for eligibility (ED history, EAT-26) and ED participants completed the EDE v17.0D. Each participant undertook a one-on-one experimental session with a researcher over Zoom, lasting approximately 1.5–2 hours, following a structured protocol (see [40] for procedural details). Participants were required to be seated at a laptop or computer positioned directly in front of them, approximately 50 cm away and aligned with eye level.

As depicted in Figure 1a, the session involved a baseline condition comprising a self-face recognition task and state-based body and face image measures. Participants then completed two visuomotor illusion induction conditions in a counterbalanced order. In the synchronous condition, participants observed the stimulation video and mimicked the model's expressions in real-time (e.g., smiled when the model smiled) (Figure 1b). In the asynchronous condition, participants watched the same video but performed the opposite facial expressions to the model (e.g., smiled when the model was neutral). Each condition involved two facial mimicry trials (150 seconds per trial), followed by measures of objective and subjective enfacement and then state-based face and body image (randomised). A 5-minute break between conditions minimised carryover effects. Model identity was consistent across the stimulation video and self-face recognition task.

After completing both conditions, participants provided demographic information and were debriefed. All questionnaires/scales were delivered via Qualtrics. Self-face recognition and mimicry tasks were administered through PowerPoint, which participants opened locally in full-screen mode and screen-shared for monitoring.

## Statistical Analyses

Given the nested data structure (Level 1: repeated measures; Level 2: participants), two multilevel models (MLMs) with random intercepts were tested. Fixed effects included Time (synchronous = 0, asynchronous = 1; synchronous = 0, baseline = 1), Group (control = 0, ED = 1), their interaction (Time  $\times$  Group), and mean-centred age. Only age was controlled for due to sample size constraints and its established links to ED symptoms [50,51] and enfacement outcomes [52].

The first model tested differential susceptibility to the enfacement illusion (H1), using EQ scores (total and subscales) across synchronous versus asynchronous conditions, and self-face recognition task scores across synchronous versus asynchronous and synchronous versus baseline conditions. Stronger enfacement was indicated by higher EQ scores and lower recognition scores in the synchronous condition. A Time  $\times$  Group interaction tested group differences in these changes.

The second model evaluated changes in face and body image post-enfacement—facial attractiveness, facial adiposity (single-item scales), and head/body dissatisfaction (BSS subscales)—comparing synchronous versus baseline conditions (H2). Improvements were defined as increased facial attractiveness and reduced scores on the remaining measures in the synchronous condition. A Time  $\times$  Group interaction tested group differences in these changes (H3). Only the synchronous versus baseline comparison was examined given prior evidence from embodiment illusion studies that greater body image improvements occur following synchronous compared to asynchronous conditions (for reviews, see [15,53]).

Significant effects were explored via estimated marginal means with Bonferroni-corrected pairwise comparisons. Model fit was assessed using marginal  $R^2$  (fixed effects), conditional  $R^2$  (fixed and random effects) [54], and semi-partial  $R^2$  via the SGV method [55]. Analyses were conducted in R Studio (v4.4.1) using the *lme4*, *lmerTest*, and *emmeans* packages [56,57].

## Results

### *Assumptions Checking*

Multicollinearity was within acceptable limits (Variance Inflation Factor scores  $< 5$ ). Shapiro-Wilk tests indicated normality violations (H2-H3), and residual plots suggested potential heteroscedasticity for one model. To enhance robustness, we applied Satterthwaite approximations for degrees of freedom and computed 95% confidence intervals across models. Several outliers (standardised residuals  $> 3$ ) were identified, but Cook's Distance ( $> 4/N$ ) showed no undue influence; all cases were retained to preserve power and sample representativeness. Intraclass correlation coefficients supported the multilevel structure (Table 3).

### *Susceptibility to Enfacement*

#### *Subjective Enfacement*

MLM analyses (Table 3) revealed a significant main effect of Time for the self-identification subscale of the EQ (semi-partial  $R^2 = 3\%$ ), with higher scores in the synchronous (versus asynchronous) condition, indicating an enfacement effect across the entire sample. Average self-identification scores across conditions fell below the scale's affirmative range, suggesting such an effect was weak (see Table 2 for descriptive statistics). No significant main effect of Time emerged for the total EQ score or affect and similarity subscale scores ( $R^2 = 0\text{--}1\%$ ). No significant main effect of Group ( $R^2 = 0\%$ ) or Time  $\times$  Group interactions ( $R^2 = 0\text{--}2\%$ ) emerged. The models explained 43–67% of the total variance (5–10% unique variance).

#### *Objective Enfacement*

A significant **main effect of Time** ( $R^2 = 1\%$ ) showed **lower self-face recognition task scores following** synchronous (but not asynchronous) compared to baseline conditions (average reduction of 6.88% of 'self' required for self-identification), indicating an enfacement effect across the entire sample. There was no significant main effect for Group or Time  $\times$  Group interactions (all  $R^2 = 0\%$ ). The model explained 82% of the total variance (4% unique).

### *Face and Body Image Changes Post-Enfacement*

At baseline, ED participants reported **greater head and body dissatisfaction, higher perceived facial adiposity, and lower perceived facial attractiveness** (near scale extremes) than controls (around or below scale midpoints) (Table 2).

#### *Facial Attractiveness and Adiposity*

No significant main effect of Time or Time  $\times$  Group interactions emerged for either outcome ( $R^2 = 0\text{--}1\%$ ). A significant main effect of Group emerged for attractiveness ( $R^2 = 12\%$ ), but not adiposity ( $R^2 = 5\%$ ), with ED participants reporting lower perceived facial attractiveness than controls across conditions. The model's total variance explained was 85% for attractiveness (23% unique) and 75% for adiposity (24% unique).

#### *Head and Body Dissatisfaction*

There was no significant main effect of Time for either outcome ( $R^2 = 0\%$ ) or Time  $\times$  Group interaction for body dissatisfaction ( $R^2 = 0\%$ ). However, there was a significant Time  $\times$  Group interaction for head dissatisfaction ( $R^2 = 1\%$ ), indicating that the magnitude of change differed between groups. Post-hoc pairwise comparisons (Figure 3) within the ED group revealed significantly greater head dissatisfaction post-synchronous versus baseline conditions ( $b = 2.84$ ,  $SE = 0.91$ ,  $t = 3.12$ ,  $p = 0.003$ ), with estimated marginal means of 36 and 33 ( $SE$ 's = 1.9), respectively. No significant timing effects emerged among controls ( $b = -0.67$ ,  $SE = 0.81$ ,  $t = -0.82$ ,  $p = 0.415$ ), with estimated marginal means of 17 and 18 ( $SE$ 's = 1.7) for synchronous and baseline conditions, respectively. The main effect of Group was significant for both outcomes ( $R^2 = 40\text{--}48\%$ ), with ED participants reporting greater dissatisfaction than controls across conditions. The models explained 94% and 98% of the total variance (51–62% unique) for head and body dissatisfaction, respectively.



**Table 1.** Participant Demographic and Clinical Characteristics.

Variable	Group			$t/\chi^2$	$p$
	ED ( $n = 19$ )	Control ( $n = 24$ )	Total ( $N = 43$ )		
Age ( $M \pm SD$ )	27.47 $\pm$ 10.70	21.50 $\pm$ 4.77	24.14 $\pm$ 8.40	-2.45	<b>0.019</b>
BMI ( $M \pm SD$ )	21.15 $\pm$ 7.00	22.60 $\pm$ 3.55	21.96 $\pm$ 5.34	0.89	0.381
Primary language spoken at home ( $n, \%$ )				2.55	0.110
English	19 (100.0%)	21 (87.5%)	40 (93.0%)		
Other	0 (0.0%)	3 (12.5%)	3 (7.0%)		
Highest education completed ( $n, \%$ )				11.18	<b>0.048</b>
Year 12 or below	7 (36.8%)	15 (62.5%)	22 (51.2%)		
Certificate/diploma	4 (21.0%)	0 (0.0%)	4 (9.4%)		
Bachelor's degree	5 (26.3%)	4 (16.7%)	9 (20.9%)		
Postgraduate degree (e.g., Honours, Masters, PhD)	3 (15.8%)	5 (20.8%)	8 (18.6%)		
Sexual orientation ( $n, \%$ )				4.13	0.388
Heterosexual	11 (57.9%)	16 (66.7%)	27 (62.8%)		
Lesbian/gay	1 (5.3%)	0 (0.0%)	1 (2.3%)		
Bisexual	4 (21.1%)	6 (25.0%)	10 (23.3%)		
Asexual	2 (10.5%)	0 (0.0%)	2 (4.7%)		
Other	1 (5.3%)	2 (8.3%)	3 (7.0%)		
Marital status ( $n, \%$ )				3.51	0.320
Single	11 (57.9%)	12 (50.0%)	23 (53.5%)		
Relationship (including open relationship)	4 (21.1%)	8 (33.3%)	12 (27.9%)		
Married	2 (10.5%)	0 (0.0%)	2 (4.7%)		
De facto	2 (10.5%)	4 (16.7%)	6 (14.0%)		
ED diagnosis type ( $yes, \%$ ) <sup>a</sup>				-	-
Anorexia nervosa (restricting)	6 (31.6%)	-	-		
Anorexia nervosa (binge-purge)	2 (10.5%)	-	-		
Bulimia nervosa	2 (10.5%)	-	-		
OSFED <sup>b</sup>	9 (47.4%)	-	-		

Variable	Group			$t/\chi^2$	$p$
	ED ( $n = 19$ )	Control ( $n = 24$ )	Total ( $N = 43$ )		
ED diagnosis duration (years) ( $M \pm SD$ )	5.31 $\pm$ 8.13	-	-	-	-
Average age of ED onset (years) ( $M \pm SD$ )	22.16 $\pm$ 9.72	-	-	-	-
EDE interview score ( $M \pm SD$ )				-	-
Global severity	4.02 $\pm$ 0.99	-	-		
Restraint	3.99 $\pm$ 1.26	-	-		
Eating concern	3.12 $\pm$ 1.13	-	-		
Weight concern	4.87 $\pm$ 0.94	-	-		
Shape concern	4.56 $\pm$ 1.12	-	-		
EAT-26 score ( $M \pm SD$ )	46.58 $\pm$ 13.05	2.79 $\pm$ 1.56	22.14 $\pm$ 23.63	-14.54	<b>&lt;0.001</b>

Note. BMI = Body Mass Index (kg/m<sup>2</sup>); ED = eating disorder; OSFED = other specified feeding or eating disorder;  $M$  = mean;  $SD$  = standard deviation; EDE = Eating Disorder Examination interview v 17.0D (Cooper & Fairburn, 1987; Fairburn et al., 2018); EAT-26 = Eating Attitudes Test-26 item questionnaire (Garner et al., 1982).  $t$ -test for continuous variables, chi-squared test for categorical variables. <sup>a</sup> ED diagnosis type verified via the EDE interview. <sup>b</sup> OSFED types included atypical anorexia nervosa ( $n = 2$ ), binge-eating disorder (of low frequency or limited duration) ( $n = 1$ ), bulimia nervosa (of low frequency or limited duration) ( $n = 4$ ), and purging disorder ( $n = 2$ ). Significant (two-sided)  $p$  values are bolded.

**Table 2.** Descriptive Statistics for Outcome Variables.

Outcome variable	Time	Total ( $N = 43$ )			ED ( $n = 19$ )			Control ( $n = 24$ )			
		$M$	$SD$	Observed range	$M$	$SD$	Observed range	$M$	$SD$	Observed range	Possible range
Subjective enfacement	Total	-0.22	1.31	-2.67–1.67	-0.38	1.24	-2.67–1.67	-0.09	1.37	-2.67–1.67	-3.00–3.00
	Async	-0.68	1.17	-3.00–1.92	-1.01	1.13	2.67–1.67	-0.42	1.17	-2.67–1.83	
Self-identification	Sync	-0.99	1.53	-3.00–1.75	-1.17	1.56	-3.00–1.75	-0.84	1.52	-3.00–1.75	-3.00–3.00
	Async	-1.53	1.35	-3.00–1.50	-1.57	1.24	-3.00–1.25	-1.50	1.46	-3.00–1.50	
Similarity	Sync	-0.24	1.93	-3.00–2.50	-0.53	1.93	-3.00–2.50	-0.02	1.94	-3.00–2.50	-3.00–3.00
	Async	-0.77	1.80	-3.00–2.50	-1.21	1.72	-3.00–2.50	-0.42	1.82	-3.00–2.00	
Affect	Sync	0.57	1.62	-3.00–3.00	0.55	1.85	-3.00–3.00	0.58	1.45	-2.00–3.00	-3.00–3.00
	Async	0.24	1.42	-3.00–2.50	-0.26	1.61	-3.00–2.50	0.65	1.12	-2.00–2.00	

Objective enfacement	Baseline	60.96	16.28	27.73–95.54	61.42	19.29	41.88–90.00	60.59	13.87	27.73–95.54	0–100
	Sync	54.08	16.91	17.00–96.02	53.66	18.07	27.80–88.00	54.41	16.31	17.00–96.02	
	Async	55.34	16.44	22.54–92.00	56.98	16.46	22.54–92.00	54.04	16.67	29.12–86.49	
Facial attractiveness	Baseline	2.23	1.59	0–5	1.32	1.53	0–5	2.96	1.23	1–5	0–6
	Sync	2.40	1.64	0–5	1.58	1.57	0–5	3.04	1.40	1–5	
	Async	2.26	1.72	0–5	1.53	1.78	0–5	2.83	1.46	0–5	
Facial adiposity	Baseline	3.95	0.97	2–6	4.47	1.07	2–6	3.54	0.66	2–5	1–6
	Sync	3.70	1.15	1–6	4.16	1.38	1–6	3.33	0.76	2–6	
	Async	3.65	1.17	0–6	4.05	1.54	0–6	3.33	0.64	2–5	
Head dissatisfaction	Baseline	24.44	10.94	7–48	32.53	9.13	14–48	18.04	7.53	7–35	7–49
	Sync	25.33	12.03	7–47	35.37	8.19	17–47	17.38	7.91	7–35	
	Async	26.16	12.28	7–48	36.26	9.37	17–48	18.17	7.47	7–32	
Body dissatisfaction	Baseline	28.09	11.54	7–47	38.26	7.02	25–47	20.04	7.17	7–33	7–49
	Sync	28.09	12.59	7–49	39.11	7.88	24–49	19.38	7.83	7–37	
	Async	28.72	12.46	7–49	39.42	7.83	25–49	20.25	8.13	7–41	

Note. *M* = mean; *SD* = standard deviation; sync = synchronous; async = asynchronous. Objective enfacement scores show the mean % of frames for which the face was perceived as looking more like “self” than “other”.

**Table 3.** Fixed Effects Results for Outcome Variables, Random Effects, and Model Fit.

Outcome variable	Fixed effects	<i>b</i>	<i>b</i> 95% CI [LB, UB]	<i>SE</i>	<i>df</i>	<i>p</i>	Random effects		Conditional R <sup>2</sup> <sup>a</sup>	Marginal R <sup>2</sup> <sup>b</sup>	Semi-partial R <sup>2</sup> <sup>c</sup>	ICC
							(variance)					
							Intercept	Residual				
Subjective enfacement												
Total	Time: async	-0.33	[-0.84, 0.18]	0.26	41.00	0.212	0.72	0.81	.51	.08	.01	.47
	Group: ED	-0.18	[-0.96, 0.60]	0.40	63.08	0.655					.00	
	Age	-0.02	[-0.06, 0.02]	0.02	40.00	0.390					.01	
	Time: async * ED	-0.30	[-1.07, 0.47]	0.39	41.00	0.445					.00	
Self-identification	Time: async	-0.66	[-1.15, -0.17]	0.25	41.00	<b>0.012</b>	1.39	0.75	.67	.05	.03	.65

Similarity	Group: ED	-0.21	[-1.14, 0.72]	0.48	54.35	0.665						.00
	Age	-0.02	[-0.07, 0.03]	0.03	40.00	0.447						.01
	Time: async * ED	0.26	[-0.48, 1.00]	0.38	41.00	0.490						.00
	Time: async	-0.40	[-1.12, 0.33]	0.37	41.00	0.292	1.68	1.64	.55	.10	.01	.51
	Group: ED	-0.19	[-1.34, 0.97]	0.59	61.34	0.754						.00
Affect	Age	-0.05	[-0.11, 0.01]	0.03	40.00	0.093						.05
	Time: async * ED	0.29	[-1.38, 0.80]	0.56	41.00	0.607						.00
	Time: async	0.06	[-0.60, 0.73]	0.34	41.00	0.854	0.90	1.38	.43	.07	.00	.40
	Group: ED	-0.15	[-1.10, 0.81]	0.49	66.66	0.766						.00
	Age	0.02	[-0.03, 0.07]	0.02	40.00	0.443						.01
Objective enfacement	Time: async * ED	-0.87	[-1.88, 0.12]	0.51	41.00	0.092						.02
	Time: baseline	6.18	[2.02, 10.34]	2.12	82.00	<b>0.005</b>	0.91	0.44	.82	.04	.01	.81
	Time: async	-0.37	[-4.53, 3.78]	2.12	82.00	0.861						.00
	Group: ED	-0.35	[-11.14, 10.45]	5.51	50.31	0.950						.00
	Age	-0.07	[-0.68, 0.54]	0.31	40.00	0.830						.00
Facial attractiveness	Time: baseline * ED	1.58	[-4.68, 7.83]	3.19	82.00	0.622						.00
	Time: async * ED	3.69	[-2.56, 9.94]	3.19	82.00	0.251						.00
	Time: baseline	-0.08	[-0.45, 0.28]	0.18	41.00	0.654	1.67	0.41	.85	.23	.00	.80
	Group: ED	-1.51	[-2.43, -0.59]	0.47	47.57	<b>0.002</b>						.12
	Age	0.01	[-0.05, 0.06]	0.03	40.00	0.781						.00
Facial adiposity	Time: baseline * ED	-0.18	[-0.72, 0.36]	0.28	41.00	0.521						.00
	Time: baseline	0.21	[-0.10, 0.51]	0.16	41.00	0.190	0.61	0.29	.75	.24	.01	.67
	Group: ED	0.62	[0.01, 1.22]	0.31	53.26	0.051						.05
	Age	0.04	[0.00, 0.07]	0.02	40.00	<b>0.047</b>						.08
	Time: baseline * ED	0.11	[-0.35, 0.57]	0.24	41.00	0.650						.00
Head dissatisfaction	Time: baseline	0.67	[-0.92, 2.25]	0.81	41.00	0.415	57.84	7.88	.94	.51	.00	.88
	Group: ED	19.13	[13.93, 24.33]	2.66	44.44	<b>&lt;0.001</b>						.40
	Age	-0.19	[-0.49, 0.11]	0.15	40.00	0.226						.03

Body dissatisfaction	Time: baseline * ED	-3.51	[-5.90, -1.12]	1.22	41.00	<b>0.006</b>					.01	
	Time: baseline	0.67	[-0.39, 1.72]	0.54	41.00	0.223	52.38	3.49	.98	.62	.00	.94
	Group: ED	19.14	[15.85, 25.46]	2.45	42.25	<b>&lt;0.001</b>					.48	
	Age	-0.15	[-0.44, 0.13]	0.14	40.00	0.292					.03	
	Time: baseline * ED	-1.51	[-3.10, 0.08]	0.81	41.00	0.070					.00	

*Note.* CI = confidence interval; LB = lower bound; UB = upper bound; sync = synchronous; async = asynchronous; ED = eating disorder; b = regression coefficient; SE = standard error; ICC = intraclass correlation coefficient. <sup>a</sup> = variance explained by fixed and random effects; <sup>b</sup> = shared variance explained by fixed effects; <sup>c</sup> = unique variance explained by each fixed effect. Reference categories (Time = synchronous; Group = control) were assigned a value of 0; whilst categories shown in the table (Time = baseline, asynchronous; Group = ED) were assigned a value of 1. Significant *p* values (<.05) bolded.



## Discussion

This study investigated the malleability of self-face representation in EDs and the therapeutic potential of the enfacement illusion, a multisensory integration paradigm previously unexplored in clinical ED samples. ED and control participants showed comparable susceptibility to the illusion, and neither group showed improvements in face or body image disturbance following the task. Instead, ED participants selectively reported *increased* dissatisfaction with their head region.

### Enfacement Susceptibility

Contrary to expectations, ED and control participants showed comparable susceptibility to the enfacement illusion across subjective and objective measures, as indexed by self-reported self-identification with the model and a self-other attribution bias following synchronous stimulation. Such findings mirror those in a recent community study observing equivalent enfacement susceptibility across low and high-ED-risk groups [37]. This pattern contrasts with consistent evidence of *heightened* susceptibility to bodily illusions in clinical ED samples [17,19]. The dissociation suggests that facial (unlike bodily) representations may retain normative multisensory flexibility in subclinical and clinical ED populations. This does not negate the occurrence of facial distortions in EDs but instead implies that such distortions—as observed in reduced facial recognition accuracy and negative evaluations [31,32]—may arise from mechanisms distinct from those underpinning body distortions. Such a face-body dissociation is broadly supported by neuroimaging evidence suggesting partial anatomical and functional separation of face and body processing systems [58,59].

The current findings may be contextualised within a predictive coding framework [60,61], according to which perception is an inferential process shaped by the interaction between bottom-up sensory inputs and top-down expectations (based on prior knowledge and beliefs within internal mental models). Under this model, any discrepancy between expected and actual sensory input generates a prediction error, which the brain attempts to resolve either by updating internal models or reinterpreting the sensory data to fit prior beliefs. The strategy employed depends on the relative precision or reliability of each source of information. Embodiment illusions, including the enfacement illusion, are a powerful means to study these dynamics. The enfacement illusion in the present study arises when synchronised visuo-motor stimulation between one's own and another's face creates a prediction error that is resolved by incorporating external sensory signals (e.g., the other's facial features) into one's self-representation. Heightened susceptibility to embodiment illusions in ED populations has been interpreted as reflecting an overreliance on rigid prior beliefs at the expense of incoming sensory input which is deemed less reliable, possibly due to known deficits in multisensory integration in EDs, namely, an overreliance on visual information about the body relative to somatosensory information (e.g., [16,62]). This imbalance may promote the persistence of distorted body representations in EDs, whereby rigid and maladaptive pre-existing expectations about the body (e.g., prior beliefs of being overweight) are over-relied upon at the expense of conflicting sensory information [62].

Importantly, while predictive coding frameworks have been applied to explain top-down distortions in bodily representations among individuals with EDs, the current findings suggest that this model may not extend as readily to self-face representations. One possible reason is that self-face representations, despite being emotionally salient [32], may be less affected by top-down distortions than bodily representations in EDs. Indeed, body image distortions in EDs tend to be **global**, affecting the body as a whole: although some evidence points to **localised concerns**, these centre more on weight-relevant body regions (e.g., stomach, thighs) than on the face [5,63]. Furthermore, research has shown that individuals with AN direct more visual attention toward body stimuli than to faces during passive viewing tasks (e.g., via eye-tracking) [64], suggesting that the self-face in EDs may be a lesser source of emotional or appearance-based information. Together, these findings suggest that self-face representations might be less affected than the body by top-down distortions in EDs, thus, allowing for normal integration of bottom-up sensory bodily information and resulting in typical levels of facial malleability among ED participants and comparable enfacement illusion susceptibility to control participants.

It is also worth considering the possibility that the enfacement illusion lacks sensitivity to detect subtle differences in multisensory integration between ED and control participants. The subjective experience of enfacement was modest, as indicated by subjective scores generally falling below the

scale's affirmative range—a pattern consistent with previous enfacement research, unlike the typically observed more affirmative scores in embodiment research [22]. Since the face, unlike the body, often plays a central role in identity [34], and face recognition is a highly practised, socially important skill that continues to improve in early adulthood [65], this may render self-face representations more stable and less amenable to recalibration via brief multisensory stimulation. However, robust direct comparisons have yet to be published on this issue.

### Enfacement as an Intervention

Contrary to expectations, experiencing the enfacement illusion did not improve face or body image disturbance in ED or control participants. Instead, head dissatisfaction increased for participants with an ED following the illusion. This finding aligns with previous research suggesting that experiencing enfacement may exacerbate rather than alleviate head/body dissatisfaction in individuals with elevated ED symptomatology [37]. The null results on other outcomes should be interpreted cautiously, given potential limitations in measurement sensitivity.

One explanation for the increase in head dissatisfaction lies in the interpersonal nature of the enfacement illusion. Unlike embodiment, the modest illusory effect of enfacement might have preserved self-other boundaries, rendering the task more socially charged than purely perceptual, especially since the face plays a central role in social communication [24]. In ED participants, this may have triggered affective or interpersonal discomfort. Individuals with EDs typically avoid visually attending to faces [64,66]. Since the enfacement illusion task required participants to maintain constant visual engagement with a stranger's face, if such avoidance reflects a protective mechanism against social discomfort, the task may have evoked feelings of self-consciousness. For individuals with EDs who frequently report heightened sensitivity to perceived negative social evaluation, especially appearance-based [27], the task may have specifically evoked concerns around judgment and rejection, and subsequently self-consciousness of one's facial appearance, driving head dissatisfaction. Furthermore, ED individuals tend to avoid attending to emotionally expressive faces [64,66] and because these individuals tend to show negative interpretation biases of social stimuli [67] even simple social cues like watching a model's face alternating between smiling and neutral expression might have been misinterpreted as signals of rejection, increasing head dissatisfaction. Post-task participant reflections support these interpretations: most ED participants described heightened appearance concerns after the illusion, and many reported discomfort with the model's gaze, including feelings of judgment and self-consciousness—patterns not seen in controls. In this sense, self-face perception in EDs may be driven by a deeper unease with self-other dynamics (e.g., interpersonal evaluation), with face-related dissatisfaction emerging primarily in contexts that increase social self-awareness.

From a neurocognitive perspective, the Allocentric Lock Theory [69,70] offers a complementary explanation. This theory posits that individuals with EDs are “locked” into a negative, third-person (allocentric) body representation that resists updating from first-person (egocentric) sensory cues. If the enfacement illusion fails to elicit a strong sense of self-identification with the model's face, this lack of egocentric updating may have unintentionally reinforced negative allocentric representations, thereby increasing head dissatisfaction.

Interestingly, this dissatisfaction was specific to the head. One possibility is that while the body holds more entrenched cognitive-affective salience in EDs, the face becomes more only in social contexts that provoke interpersonal evaluation. The null effects on facial attractiveness and adiposity may reflect poor measurement sensitivity as these outcomes were assessed with single-item scales lacking psychometric validation. In contrast, the head dissatisfaction scale, as a composite measure of multiple facial features, may have better detected localised appearance concerns. Individuals with EDs, especially AN, display a feature-focused visual bias away from salient facial features (e.g., eyes, mouth) [66]. Since these regions convey social information (e.g., emotion, gaze), avoidance may reflect anxiety around social judgement. Over time, this pattern may reinforce associations between these regions and perceived scrutiny, inadvertently increasing dissatisfaction with specific aspects of the face.

### Strengths and Limitations

Study strengths include the clinically verified ED sample, reducing misclassification biases common in embodiment illusion research [15] and a comprehensive battery of face and body evaluation measures alongside controlled comparisons between synchronous and asynchronous

stimulation conditions, enhancing internal validity. While the sample size was modest, it is consistent with prior embodiment studies in clinical ED populations [71–73]. Nonetheless, the study may have been underpowered to detect subtle effects or interactions, particularly given the small effect sizes observed (1–3% unique variance explained).

Including a mixed ED sample reflects clinical reality, given symptom overlap across diagnoses [74], and aligns with previous embodiment research [16,17,21]. Nonetheless, this approach may have obscured diagnosis-specific effects, especially as multisensory integration abnormalities are better established in AN [62].

Future research should employ larger, diagnostically stratified samples and ensure sufficient power to account for relevant covariates such as BMI and alexithymia.

Further limitations include the non-validated, single-item measures of facial attractiveness and adiposity, which may not adequately capture the complexity of self-face representation. Future work should incorporate validated psychometric tools and objective indices (e.g., eye-tracking, facial metrics) to enhance measurement precision. Additionally, the use of ‘average’ faces may have confounded responses; attractive faces are known to strengthen enfacement [44], yet, if self-other boundaries are preserved during enfacement, incorporating attractive faces may provoke adverse responses in ED populations (e.g., via upward appearance comparisons [75]). Tailoring facial stimuli to individual social-affective profiles, such as by enhancing model likeability or reducing perceived social threat, could improve therapeutic utility.

Finally, findings may not generalise beyond White cisgender women. Given that cultural and gender differences in body and face image are well-documented [76,77], future enfacement research should examine whether enfacement effects differ across diverse populations (for discussion, see [78]). For instance, cultural schemas may shape the domains (face versus body) around which ED-related perceptual biases consolidate.

#### **Future Research Directions and Clinical Implications**

The current findings, pending replication, highlight the potentially complex and context-dependent nature of self-face perception in EDs, offering several implications for theory and practice. While susceptibility to the enfacement illusion was comparable across ED and control groups, the affective consequences of the illusion diverged, suggesting that it is not sensory integration per se, but the social *meaning* attributed to the task that may drive negative outcomes in ED individuals. In this sense, self-face perception in EDs may be shaped less by deficits in bottom-up multisensory integration, and more by entrenched top-down beliefs related to social evaluation and interpersonal self-consciousness.

Future research should prioritise disentangling the perceptual and socio-emotional dimensions of the enfacement illusion. ED-relevant traits such as alexithymia, autism spectrum characteristics [79,80], social anxiety, and rejection sensitivity [27], should be systematically examined. These factors may influence how ED individuals experience self-other overlap—e.g., alexithymia and autism spectrum characteristics have been shown to embodiment susceptibility (either attenuating or strengthening it) outside of ED contexts [81]—or whether they interpret the illusion as an emotionally-charged social encounter that drives self-consciousness.

In line with predictive coding frameworks, the affective consequences of the illusion may arise from the interplay between incoming sensory input (e.g., seeing the model’s face) and rigid, maladaptive socially-driven prior beliefs (e.g., “others judge my appearance negatively”). Future researchers should therefore investigate how individuals with EDs perceive social evaluation, particularly beliefs about being judged due to their ED and discomfort with their face being seen or judged, and assess how these priors moderate enfacement outcomes. Moreover, research should examine whether self-face representations in EDs are indeed less distorted due to their weaker emotional salience, or whether they become distorted only within certain social contexts.

Clinically, the current findings of increased head dissatisfaction in ED participants post-enfacement prompt caution against enfacement-based interventions for EDs that do not account for the social dynamics embedded in the task. Nonetheless, these findings do not discourage future research into enfacement-based interventions for EDs. Prior evidence supports the potential for enfacement to recalibrate and improve face and body image disturbance in individuals with low levels of ED symptoms [37], suggesting the illusion may have preventive or subclinical applications. However, for clinical ED groups, interventions may need to be adapted, such as by incorporating features that promote social safety and emotion regulation (e.g., non-judgmental facial expressions,

averted gaze, or cognitive reappraisal techniques) or by reducing the social significance of the illusion (e.g., using avatars instead of real models).

## Conclusions

Our findings underscore a potential dissociation in how multisensory processes contribute to face versus body image disturbance in EDs. While enfacement illusions may not offer universal therapeutic benefits for EDs, it may not be the illusion's perceptual strength that matters most, but rather how the experience is interpreted **on a socio-emotional level**. Future researchers should investigate how interpersonal processing shapes self-perception in EDs and how enfacement interventions can be better tailored to these dynamics to enhance their therapeutic potential.

## Declarations

### CRediT Author Contributions Statement

**Jade Portingale:** Conceptualization, Methodology, Investigation, Formal Analysis, Data Curation, Project Administration, Visualization, Writing – Original Draft, Writing – Review & Editing. **David Butler:** Conceptualization, Methodology, Supervision, Writing – Review & Editing. **Isabel Krug:** Conceptualization, Methodology, Project Administration, Supervision, Writing – Review & Editing.

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## Ethical Standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the National Health and Medical Research Council (NHMRC) Human Research Ethics Committee and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all subjects involved in the study. All authors have provided consent for publication. Informed consent has been obtained from all subjects for publication of identifying images used in the Figure in an online open-access publication.

## Competing Interests

The authors have no conflicts of interest to declare.

## Data Availability

The datasets analysed during the current study are available from the corresponding author upon request.

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