Title: The effects of body exposure on self-body image and esthetic appreciation in Anorexia Nervosa

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Abstract

Repeated exposures to thin-idealized body shapes may alter women's perceptions of what normal (e.g., accepted) and ideal (e.g., desired) bodies in a cultural environment look like. The aim of the present study was to investigate whether exposure to slim and round body shapes may change the subsequent esthetic appreciation of others' bodies and the perceptual and cognitive-affective dimensions of self-body image in patients suffering from Anorexia Nervosa (AN). Thirteen AN patients and 13 matched healthy controls were exposed to pictures of either slim or round unfamiliar body models and, before and after exposure, they were required to either express **liking** judgments about round and slim figures of unfamiliar bodies (Esthetic Task) or to adjust distorted pictures of their own body to their **perceptual (How do you see yourself?), affective (How do you feel yourself?), metacognitive (How do others see you?) and ideal (How would you like to look like?) body image (Self-body adjustment task)**. **Brief exposures to round models increased liking judgments of round figures in both groups**. **However, only in AN patients exposure to round models induced an increase of slim figures liking,** which positively correlated with their preoccupation with dieting. **Furthermore, exposure to round bodies in AN patients, but not in controls, increased the distortion for the perceptual body image and decreased the size of the ideal one**. No differences between the two groups were obtained after adaptation to slim models. Our results suggest that AN patients' perception of their own and others' body is more easily malleable by exposure to round figures as compared to controls. Crucially, **this mechanism** may strongly contribute to the development and maintenance of self-body image disturbances.

Keywords: anorexia nervosa; body image; size distortion; esthetic; perceptual adaptation; eating disorders.

Introduction

Experience can change what is appreciated in human faces and bodies. One mechanism that may explain how experience influences face and body appreciation is perceptual 'after-effects', with prolonged exposure to a certain class of stimuli, such as face or body shapes (Rhodes et al. 2003), biasing perception of subsequently viewed stimuli towards the opposite direction of the adaptation stimulus (Gibson and Radner 1937; McCollough 1965). For example, after prolonged exposures to female faces, subsequently seen gender-neutral faces appear male to the observer and vice versa. Hence, face-after-effects can be observed for certain specific facial cues such as gender (Webster et al. 2004, Palumbo et al. 2015), ethnicity (Ng et al. 2008), emotional expression (Fox and Barton 2007), or gaze direction (Calder et al. 2007). Another mechanism that has been called into action in the adaptation effects on esthetic appreciation, however, is 'norm-based coding'. According to this mechanism, those stimulus categories whose exemplars share a defined perceptual structure, in particular faces and bodies, are perceptually coded as deviations from a prototype-referenced template (Valentine, 1991) and the exemplars that are more similar to the template receive higher esthetic appreciation (Valentine, Darling and Donnelly 2004). Norm-based representations may be shaped by experience (Dennett et al. 2012; Rhodes et al. 2003), shifting the esthetic appreciation system toward a preference for more familiar (i.e., adapted) stimuli.

Despite the importance of body perception and its contribution to social interaction, only a few studies have investigated the effects of adaptation to bodily cues, for example to androgynous (Palumbo et al. 2013) or to thin and round body shapes (Winkler and Rhodes' 2005). In particular, in a seminal study of the effects of perceptual adaptation on the esthetic experience of the body (Winkler and Rhodes, 2005), healthy participants adapted to either

thin or round unfamiliar virtual bodies and were asked to express attractiveness and normality judgments of distorted unfamiliar bodies before and after adaptation. The authors reported that the most attractive and most normal appearing bodies became thinner after adaptation to thin bodies. In addition, the most normal looking body changed after adaptation to round bodies, while the most attractive body did not. Glauert et al. (2009) replicated these findings using real body pictures and found that greater Body Dissatisfaction (BD) and internalization of the thin western ideal were related to having a thinner normal and ideal body, to a greater discrepancy between the most normal and the most ideal body, and to a reduced effect of adaptation to round bodies. These results show that perceptual adaptation can easily induce 'plastic change' in body perception and the magnitude of this change is related to body concerns. **BD itself is important because it is widely considered as a risk factor for eating disorders (EDs) (Stice, Ng and Shaw 2010). For instance, it is also linked with dieting, since women with an excessive preoccupation with weight and fear of weight gain, as measured by the Drive for Thinness (DT) clinical subscale, show greater levels of BD (Wiederman and Pryor 2000), bulimic symptoms, depression and lower self-esteem (Johnson and Wardle 2005; Stice 2001). Furthermore, exposure to thin media models together with higher levels of thin-ideal internalization are associated to negative emotions, such as anger, body anxiety and depression (Cattarin et al. 2000; Dittmar and Howard 2004; Durkin and Paxton 2002).** For these reasons, thin-ideal internalization together with BD and DT are considered risk factors for the development and maintenance of disordered eating (see Hausenblas et al. 2013 for a Comprehensive Review).

In light of these findings, it may be hypothesized that patients with Anorexia Nervosa (AN) present altered sensitivity to perceptual exposure to extreme ideals of body size. In keeping with this hypothesis, a previous study (Mele, Di Taranto et al. submitted) used a modified perceptual adaptation paradigm to compare the sensitivity to perceptual exposure in

adolescents with AN and age-matched controls. Rather than estimating the most attractive or normal body weight, as done in previous studies, this study measured separately how the esthetic judgments of thin and round bodies were affected by repeated exposure to thin or round models. Indeed, while perceptual after-effects and norm-based coding mechanisms are often treated interchangeably in the explanation of exposure-related changes of body appreciation, they may lead to different predictions about the effects on the esthetic appreciation of thin and round bodies. Indeed, according to perceptual after-effects, subsequently viewed bodies should appear thinner after exposure to round models and rounder after exposure to thin models. Thus, both thin and round bodies are expected to be liked more after round exposure and less after thin exposure. Conversely, norm-based coding should exert differential effects on the appreciation of thin and round models, since the more familiar (i.e., adapted) stimulus is expected to be liked more after adaptation, while less familiar (i.e., non adapted) stimulus should receive lower esthetic ratings. Thus, according to norm-based coding, after exposure to round models the observers should like more round bodies; the opposite should occur after exposure to thin models. Results in healthy adults (Mele, Cazzato and Urgesi 2013) and adolescents (Mele, Di Taranto et al. submitted) showed that the liking judgments of round bodies increased or decreased after brief exposure to round or thin models, respectively, a pattern of results that was predicted by both perceptual aftereffects and norm-based coding. No change occurred in the liking judgments of thin bodies, suggesting that the counteracting actions of perceptual aftereffects and norm-based coding cleared out any effects for thin bodies. Conversely, in adolescent patients with AN (Mele, Di Taranto et al. submitted) the esthetic ratings changed only after round exposure, with an overall increase of the esthetic value of both thin and round bodies, that was predicted by the action of perceptual after-effects with no update of norm-based coding. Exposure to thin bodies did not exert any effects in patients, probably because they had

already internalized an even-thinner ideal of body beauty. Thus, while the effects of body exposure in AN patients could be explained by only perceptual after-effects, the pattern obtained in healthy controls suggests that perceptual experience shaped esthetic appreciation to favor more familiar body figures. This reflects not only plasticity of the perceptual representation system but also changes of the ideals (or template) of body beauty, which may be more rigid in AN patients (Mele et al. 2013).

Still the question remains as to whether and how perceptual adaptation to certain body figures biases not only the esthetic appreciation of others' bodies, but also the perception of self-body shape. Patients with AN usually overestimate their own body size and shape and the exact mechanism behind this aberrant body perception in clinical disorders still needs to be clarified (Smeets and Kosslyn 2001; Smeets et al. 2009). **In light of the alterations of body exposure effects in patients with AN, it may be hypothesized that similar alterations may exist in how exposure to certain body shapes can alter the way AN patients perceive their own body shape.** In fact, exacerbated perceptual after-effects may induce persistent body image distortions of clinical relevance by on-going selective attention toward disorder-relevant stimuli, such as body shape or size (Dobson and Dozois 2004). Importantly, the perceptual bias after adaptation to bodily cues transfers across different identities. In a study of Hummel et al. (2012), participants adapted to distorted thin or round pictures of their own bodies or of the body of a different individual and subsequently rated pictures of their own bodies. The authors found that, for both exposures to their own distorted body and to an unfamiliar body model, participants judged a thinner than actual body picture to be the most realistic after adaptation to thin bodies, while the opposite occurred after round adaptation. **Hence, these perceptual mechanisms may be altered in patients with AN, so that aberrant body perceptual after-effects may transfer across identities and strongly contribute to the development and maintenance of body image disturbances in EDs.**

The aim of the present study was twofold: i) to investigate whether patients with AN show altered sensitivity to perceptual after-effects in contrast to weak recoding of body beauty ideals, ii) to investigate whether perceptual after-effects transfer to more clinically relevant subcomponents of self-body image for AN patients, such as the perceptual, **metacognitive (i.e., the ability to perceive one's own body as other people see it)**, **affective and ideal dimensions (Thompson 2004; Cazzato et al. 2015).**

We utilized the same body adaptation paradigm used in previous study (Mele et al. 2013) to adapt AN patients and controls to extremely thin or to extremely round bodies. Before and after exposure, participants either provided esthetic liking judgments on different unfamiliar bodies of variable sizes (Task 1) or adjusted their own body picture according to a series of questions assessing perceptual and cognitive-affective components of body image disturbances (Task 2). **In line with Hummel et al.' results (2012), we expected to find significant after-effects in both tasks, demonstrating an adaptation transfer across body identities. In relation to Task 1, following body size perceptual after-effects we expected that unfamiliar bodies should receive higher liking ratings after round adaptation and lower ones after thin adaptation. These effects of perceptual adaptation should be tempered in healthy controls by the simultaneous effects of norm-based recoding, which are expected to counteract the increase of esthetic appreciation of thin bodies after round exposure. Furthermore, in relation to Task 2, we argued for the hypothesis that exposure to thin or round unfamiliar bodies may alter the way AN patients and controls perceive and judge subsequently shown pictures of their own body: after adaptation to a thin model a participant should perceive pictures of her own body as being rounder than actual and vice versa. Again, we expected that these perceptual after-effects on self-body image should be stronger in AN patients than in controls.** Crucially, we expected that exposure effects should be also related to individual BD and DT, which

characterize the clinical profile of ED patients and may mediate the particular susceptibility of these individuals to the effects of socio-cultural influence on body representation.

Methods

Participants

A total of 26 women were enrolled: 13 patients with a diagnosis of AN and 13 healthy volunteers. AN patients were recruited at the 'Casa di Cura Villa Margherita' Hospital, Arcugnano, Vicenza. Patients were recruited over a 8-month period on the basis of a sequential recruitment procedure, according to which all the patients referred to as suffering from AN in the recruitment period were screened for inclusion and exclusion criteria. The main inclusion criteria was an IQ > 85 as evaluated by means of the Raven Standard Progressive Matrices test and diagnosis of AN restrictive (AN-R) or purge-binge (AN-PB) type, according to DSM-IV-TR. Patients satisfying all criteria for AN were included in the study. Exclusion criteria for patients included a history of a different type of ED; any personality or psychotic disorder; a history of traumatic brain injury or any other neurological illness; current major medical illness that may affect brain structures such as diabetes. The patients were diagnosed using the Structured Clinical Interview for DSM-IV-TR (SCID) (American Psychiatric Association, 1994) criteria by an experienced investigator and a clinical psychiatrist specialized in the psychotherapy of ED. Four patients were diagnosed as AN-R, nine patients as AN-PB (for binging behavior). No patient had a clinical history of a different ED and none had DSM-IV axis I disorders. Patients with mood or anxiety disorders were not excluded (see Table 1) to select a more representative sample of AN patients, considering the high comorbidity of ED with mood, anxiety, and personality disorders. Patients received pharmacological medication (selective serotonin reuptake inhibitors and/or benzodiazepine) at the time of testing. Five patients were taking oral contraceptives. All

patients received individual and/or group and/or familiar psychotherapy at the time of testing. Control participants were recruited from the University of Udine and from the local community by word of mouth. Exclusion criteria for controls included history of any type of ED, being under medication at the time of testing, no history of psychiatric disorders as determined with the screening section of Symptom Checklist-90 (SCL-90), no history of alcohol or substance abuse or dependence, and no current major medical condition. The demographic characteristics of the patients and controls are reported in Table 1. Patients and healthy volunteers were matched for gender, ethnicity and language and they did not differ for educational level and age. In keeping with the diagnosis, AN patients had a lower body mass index (BMI) with respect to the controls. All the participants but two patients and one control were right-handed and no difference was observed between the handedness total score of patients and controls. Thus, we can rule out that any differences between patients and controls were due to demographical and socio-cultural variables. All participants reported normal or corrected-to-normal visual acuity in both eyes. They were native Italian speakers of Caucasian race. The participants were naïve to the purpose of experiment and received information about the experimental hypothesis only after completion of the experimental tests. Informed consent was obtained from all patients and controls. The procedures were approved by the ethics committee of the Scientific Institute (IRCCS) "E. Medea" and complied with the ethical standards of the 1964 Declaration of Helsinki.

Clinical Evaluation

Standard clinical scales were administered in order to characterize the patients' disorder as compared to the controls and to provide a basis for comparing our sample of patients with those reported in previous studies (see Table 1). Participants filled out the 90-item SCL-90, a psychiatric self-report inventory measuring nine symptoms of psychopathology (Derogatis, Lipman and Covi 1973). The 34-item self-report body shape questionnaire (BSQ) measured

shape and weight concerns (Cooper et al. 1987). The body attitude test (BAT) was administered to measure subjective body experience and the attitude toward one's body (Probst et al. 1995). The Italian version of the Eating Disorder Inventory (EDI-2) was used to measure disordered eating attitudes and behaviors and personality traits common to individuals with ED (Garner 1984). The Sociocultural Attitudes Toward Appearance Questionnaire-3 (SATAQ-3) in its Italian translation was administered to assess the extent to which women endorse and strive toward prevailing cultural standards of attractiveness (Thompson et al. 2004; Stefanile et al. 2011). The analysis of the EDI-2 data revealed that the AN patients had higher scores than controls on all EDI-2 subscales with the exception of **maturity fears (i.e., the fear of facing the demands of adult life)**. Furthermore, the AN patients had higher scores than controls on the BSQ and all BAT scales. **Finally, the analysis of the SATAQ-3 data revealed that, compared to controls, patients had higher scores on the thin-ideal internalization score (Internalization-General), but they did not differ on the subscales measuring the internalization of the athletic ideal (Internalization-Athlete), the perceived feelings of pressure to conform to the Western ideals exhibited by the media (Pressures) and the recognition of the social importance of the media's messages about Western beauty ideals information (Information).**

Please insert Table 1 almost here

General Procedure

During the experimental sessions, participants sat 57 cm away from a 15.6-inch LCD monitor (resolution: 1.024 × 768 pixels; refresh frequency: 60 Hz). Two separate tasks were conducted. The first task involved liking judgments of others' body, while the second task involved perceptual and cognitive-affective judgments of self-body images. Each task consisted of an initial evaluation of the stimuli (pre-exposure phase, baseline), an exposure phase and a re-evaluation of the stimuli after exposure (post-exposure phase). **The body**

stimuli were taken from previous studies (Cazzato et al. 2012, 2014; Mele et al. 2013) and depicted two 3-D human figure virtual models (1 female), with each model rendered in different postures and with different round and thin body sizes (see Figure 1). Importantly, these stimuli have been validated in a previous study (see Cazzato, Siega and Urgesi 2012 for details) by asking participants to rate the roundness of each body stimuli by answering to the question "How much do you think the model is fat?" on a VAS scale ranging from 0: not at all to 100: very much. The results of this study showed a parametric correspondence between the perceptual judgments of participants and the intended manipulation of body weight from extremely thin to extremely round body figures, thus confirming the successful experimental manipulation of body weight. In the two main exposure conditions, participants were exposed to 8 extreme round body stimuli (round exposure) or 8 extreme thin body stimuli (thin exposure). In a third control exposure condition, participants were exposed to 8 round and 8 thin virtual body stimuli, with a 1:1 matching of the number of round and thin figures (control exposure) (see Exposure Phase for details). The 4 possible weight figures (i.e., extremely round, round, thin, extremely thin) of a different set of 4 models (2 females) were presented in the pre- and post-exposure esthetic judgment tasks (64 evaluation stimuli). Both male and female body stimuli were used to test for the gender specificity of the adaptation effects and to control for the effects of the emotional/motivational connotation of female in our samples of AN and control women. All stimuli appeared on a grey background and subtended a 10° × 9° region around the fovea. The stimulus-presentation timing and randomization were controlled with E-prime V1.2 (Psychology Software Tools Inc., Pittsburgh, PA) on a PC. Participants were tested in three daily sessions, each one corresponding to a different exposure condition. The three sessions were conducted in three separate days with a waiting period of three to ten days between each

session. The order of administration of the three exposure conditions and of the two tasks in each session was balanced between participants. In each session, participants were administered the same pre- and post-evaluation procedures.

Please insert Figure 1 almost here

Exposure Phase

The exposure stimuli were presented in three 48-trial blocks, with random presentation of male and female models, static and dynamic postures and front- and three-quarter-view body pictures, for a total of 144 stimuli. Each stimulus was presented for 1,000 ms and followed by a response frame that remained on the screen until response. The participants were asked to look carefully at the stimulus and respond as fast as possible to report the gender, posture or viewing angle of the image. For each trial, the two alternative answers were displayed below the question and the participant's task was to press a button that spatially corresponds to the correct answer. The association between the answers and the buttons was balanced between participants. This procedure ensured that participants paid attention to the different morphological aspects of the stimuli, limiting the cognitive load of the task after stimulus presentation. The exposure phase lasted about 8 min. Remarkably, we used pictures of different unfamiliar bodies as adaptation stimuli, ruling out the effects of repeated presentation of the same body identity during exposure.

Esthetic judgment task

Sixty-four evaluation stimuli were randomly presented in three blocks for a total of 192 trials, with random presentation of the four size figures, models, postures and views. The trials started with the presentation of a central fixation point lasting 500 ms, followed by the body image stimulus presented for 150 ms at the center of the screen. The experimenter

monitored eye position by continuously checking the participant's gaze during the tachistoscopic presentation. The image persistence was limited by presentation of a random-dot mask ($10° × 9°$ in size; duration: 500 ms) obtained by scrambling the corresponding body stimulus with a custom-made image segmentation software. After the mask, the question "How much do you like the model?" appeared on the screen with a vertical, 10-cm Visual Analogue Scale (VAS) ranging from "I like it very much" (score = 100) to "I do not like it at all" (score = 0). The up- and down-ward position of the anchor words on the VAS scale was balanced across participants and was always presented for each question. The participants were asked to express esthetic judgments on the body stimuli by moving the mouse cursor onto the point of the VAS corresponding to their opinion. The pre- and post-evaluation phase lasted approximately 10 min each.

Self-body distortion task

Stimuli consisted of a digital photograph of each participant taken from a frontal perspective (Canon PowerShot A400 camera in portrait orientation and with the automatic flash setting). The pictures of the participants were taken while they were standing in front of a white wall in a standardized pose (standing upright, with the arms spread horizontally and the feet closed adjacent to the wall), so that the picture showed the participant's whole body. The camera was set at 4.5 m distance from the person and the zoom setting was adjusted to a 2 m vertical layout. The size of the pictures was $768 × 583$ pixels and they were displayed on the screen of a laptop computer using a software (see below) to scale the picture along the horizontal axis. The computer program 'Body Image Revealer' (Mian and Gerbino 2009; Cazzato et al. 2015) was used to manipulate the digital picture of each participant. Such procedure has high ecological validity, because it simulates, in an experimental and controlled setting, the experience of looking at one's own body in the mirror. The software is designed to jointly and realistically manipulate different body parts (shoulder, chest, belly,

hips and thighs) leaving the surrounding environment unchanged. The face was also presented to improve the ecological validity of the test and to reinforce the self's body identification during task performance. At the beginning of the trial the picture was shown with maximal distortion level at the lower (slimmer) or upper (larger) extreme. By pressing the "up" or "down" key, participants could adjust the width of the body, thus making it to appear larger or narrower. The range of possible distortion was set at ± 50%. A value of 0% indicated the original body size. Pressing the key once distorted the picture by + 1% or − 1% (See Figure 2). Participants could adjust the degree of distortion of the picture as much as they wanted, increasing or decreasing the level of distortion until they confirmed their choice by pressing the ''Enter'' key when they thought that the current adjustment represented the best answer to the question. No time limits were given for responding, but participants were invited to respond on the basis of their first impression, avoiding to recursively wonder about their choice. The value (in %) corresponding to the final level of distortion (body distortion score, BDS) was automatically saved on a computer for offline analysis.

Please insert Figure 2 almost here

In each experimental trial, an image of the participant's body with maximal distortion (either at the narrowest or roundest extreme) appeared at the center of the monitor on a black background and subtended a 13.5° × 17.94° region. Participants were required to adjust the image of their own body, thus comparing the presented picture with a stored representation of their body, accordingly to the following questions: 'How do you see yourself?' (Perceptual body image), 'How do you think others see you?' (Metacognitive body image), 'How do you feel yourself?' (Felt body image) and 'How would you like to appear?' (Ideal body image). The 'perceptual' body image assesses the perceptual aspect of self-body image. Furthermore, since disturbances in inter-subjective representations of one's own body image may contribute to body distortion in EDs (Cazzato et al. 2015), we assessed how participants

perceived their own body in relation to others' perspective (metacognitive body image).

Finally, the 'felt' and 'ideal' body image assess the cognitive-affective aspects. During the

experimental session, 2 blocks of 6 trials were presented for each of the four questions (12

trials per question) for a total of 96 trials. Block order was balanced according to a Latin

square procedure. This way, the order of questions was counterbalanced across participants.

The initial distortion level was randomized in each block. The same protocol was used in the

pre- and post-exposure self-body distortion sessions.

Data handling

For the esthetic task, the individual mean VAS values for each condition in the evaluation

phase (64 trials per cell) were calculated and entered into analysis. Preliminary analyses

showed that both AN patients and controls expressed higher liking VAS for male than for

female models. However, the gender of the models did not interact with the effects of

exposure neither with the group factor and was not considered in further analyses.

Furthermore, a significant four-way interaction between group $\times$ time $\times$ size $\times$ exposure

[$F_{(2,48)}$ = 5.005*; p* = 0.011*; $\boldsymbol{\eta_p^2}$ = 0.173*] was found, showing different groups effects

according to the exposure condition. Thus, our main analysis design aimed to detect between

group differences in each exposure condition **and involved a series of three Mixed-model**

univariate Analyses of Variance (ANOVAs), one for each exposure, with group (AN

patients and controls) as between-subject variable and time (pre- and post-exposure) and size

(round, thin) as within-subject variables. **Further analyses tested whether the degree of**

VAS score change after body exposure reduced over time in the three blocks of the post

exposure phase and how it was correlated with the observers' body weight and body image

concerns. Therefore, we computed a post- minus pre-exposure VAS score for each participant

and exposure condition **(and post-exposure block)** in order to estimate the esthetic judgment

change (EJC) after exposure. This allowed an estimation of the esthetic value change

independently from the absolute scale used by the participants in rating the stimuli. Higher EJC values correspond to higher difference from pre- to post-exposure in esthetic judgment. **Therefore, we entered the EJC indexes into a series of three 3 × 2 mixed-model ANOVAs, one for each exposure condition, including block (block 1, block 2, block 3) and size (round, thin) as within-subject variables and group (patients, controls) as between-subject factor. Furthermore,** since previous evidence demonstrated that media have a significant and lasting impact on women' DT (Ahern, Bennett and Hetherington 2008; Hargreaves and Tiggemann 2003; Tucci and Peters 2008; Fernandez and Pritchard 2012), we tested the correlation between the EJC values and the scores at the EDI-2 DT scale, which assesses an excessive concern with dieting, preoccupation with weight and fear of weight gain. This subscale is known to reliably distinguish individuals with symptoms of AN and those without symptoms of AN (Garner, Olmstead and Polivy 1983) as also demonstrated in this study by higher values in AN patients than in controls. Previous studies have also shown that greater BD is related to a reduced effect of exposure to round bodies (Glauert et al. 2009). Thus, we tested the correlation between the performance change indexes and the individual scores at the EDI-2 BD scale, which measures the degree of dissatisfaction with one's own physical appearance.

For the self-body distortion task, the BDS % scores (calculated as absolute difference from the 0%, non-distorted level) were averaged for each participant, task, time and exposure condition (12 trials per cell). The BDS% score reflects the accuracy of the participant's estimation of her own body size, with greater value indicating greater deviation from actual size. We tested whether the three exposure conditions affected BDS % when AN patients had to adjust their image according to the different body dimensions (perceptual, metacognitive, felt, ideal body dimensions). Therefore, we performed a series of three 2 × 4 × 2 mixed-model ANOVAs including time (pre- and post-exposure) and body dimension (perceptual,

metacognitive, felt, ideal) as within-subject factors and group (patients, controls) as between-subject factor. In keeping with the analysis on the esthetic task data, separate analyses were performed for each type of exposure (round, thin and control). Finally, in the same manner as described before, we computed a post- minus pre-exposure BDS% score for each participant and exposure condition in order to estimate the body distortion score change (BDSC%) after exposure. Higher BDSC values correspond to higher difference from pre- to post-exposure in esthetic judgment.

All statistical analyses were calculated with STATISTICA 8.0 (StatSoft Inc, Tulsa, Oklahoma). The source of all significant interactions was analyzed using the Newman-Keuls post-hoc test. Effect sizes were estimated using the partial eta square measure (ηp^2). All data are reported as Mean (M) and Standard Error of the Mean (s.e.m.). A significance threshold of $p < 0.05$ was set for all effects. The Pearson's r coefficient was calculated for each correlation, separately for patients and controls. No correction procedure was used considering the explorative, follow-up nature of this correlation analysis.

Results

Round Exposure

The 3-way ANOVA on the esthetic judgments revealed significant main effects of group, time and size [all $F_{(1,24)} > 9.417$; $p < 0.005$; $\boldsymbol{\eta p^2 > 0.282}$]. The 2-way interaction of time × size was significant [$F_{(1,24)} = 4.788$; $p = 0.039$; $\boldsymbol{\eta p^2 = 0.166}$], and it was further qualified by the significant 3-way interaction of time × size × group [$F_{(1,24)} = 6.898$; $p = 0.015$; $\boldsymbol{\eta p^2 = 0.223}$]. Post-hoc comparisons revealed that patients expressed higher VAS liking judgments after round exposure than at baseline for both round (pre: 23.64 ± 2.32; post: 27.06 ± 2.41; $p = 0.014$) and thin models (pre: 51.05 ± 3.79; post: 55.04 ± 4.19; $p = 0.005$; see Figure 3A). Conversely, in controls only the liking judgments of round models increased after round

exposure with respect to baseline (pre: 36.31 ± 2.32; post: 41.42 ± 2.41; $p = 0.001$), while no changes were observed for thin models (pre: 63.39 ± 3.79; post: 62.27 ± 4.19; $p = 0.396$). **Furthermore, the difference between AN patients and controls for the post-exposure liking VAS of round bodies was also significant, because controls expressed higher VAS liking judgments for round bodies than AN patients (controls: 41.42 ± 2.41; AN patients: 27.06 ± 2.41; $p = 0.036$).** Importantly, no differences were obtained between the baseline values for the two models' size when comparing patients with controls (all $ps > 0.070$). Thin models were liked more than round models in all conditions (all $ps < 0.014$).

The 3-way ANOVA on the BDS % in the self-body distortion task revealed a main effect of group [$F_{(1,24)} = 4.32$; $p = 0.049$; $\boldsymbol{\eta p^2 = 0.153}$], with patients showing higher %BDS than healthy controls (13.74 ± 1.64 vs. 8.92 ± 1.64). The 2-way interaction of time × body dimension [$F_{(3,72)} = 3.193$; $p = 0.029$; $\boldsymbol{\eta p^2 = 0.117}$] was also significant, and it was further qualified by a significant 3-way interaction of time × body dimension × group [$F_{(3,72)} = 2.986$; $p = 0.037$; $\boldsymbol{\eta p^2 = 0.111}$]. Post-hoc comparisons revealed that while in AN patients the BDS% for the 'perceptual body image' increased from pre- to post-exposure time (pre: 12.1 ± 2.13 vs. post: 14.28 ± 2.06, $p = 0.026$), healthy controls did not show any difference between these two conditions (pre: 8.48 ± 2.13 vs. post: 8.02 ± 2.06, $p = 0.899$). Furthermore, a trend toward significance was found for the 'ideal body dimension', as AN patients demonstrated a decrease of BDS% from pre- to post-exposure time (pre: 14.92 ± 1.92 vs. post: 12.37 ± 1.68, $p = 0.06$), which instead was not observed in healthy controls (pre: 12.46 ± 1.92 vs. post: 11.99 ± 1.68, $p = 0.891$). No significant exposure effects were observed in patients and controls for the metacognitive and felt body image (all $p_s > 0.394$), suggesting that exposure to round models did not affect the metacognitive and affective dimensions of body image. BDS% mean values and s.e.m. are displayed in Figure 4A.

Thin Exposure

The 3-way ANOVA on the esthetic judgments revealed significant main effects of group and size [all $F_{(1,24)} > 7.178$; $p < 0.013$; $\eta p^2 > 0.230$], but not of time [$F_{(1,24)} = 0.890$; $p = 0.355$; $\eta p^2 = 0.036$]. Thus, patients provided lower ratings than controls and both groups valued more thin than round model bodies. However, no 2- or 3-way interactions between group, time and size did reach the significance threshold [all $F_{(1,24)} < 1.916$; $p > 0.179$; $\eta p^2 < 0.074$], suggesting that exposure to thin bodies did not affect the esthetic judgments of thin and round models both in patients and in controls (see Figure 3B).

The 3-way ANOVA on the BDS % revealed a main effect of group [$F_{(1,24)} = 7.012$; $p < 0.001$; $\eta p^2 = 0.819$], with patients showing higher %BDS than healthy controls (15.41 ± 1.67 vs. 9.16 ± 1.67). Furthermore, the significant 2-way interaction of body dimension × group [$F_{(3,72)} = 2.910$; $p = 0.04$; $\eta p^2 = 0.108$] revealed that healthy controls showed greater distortion for the 'ideal dimension' as compared to the other body dimensions (all $p_s < 0.040$). No such a difference among the four body dimensions was observed in AN patients (all $p_s > 0.513$). Finally, the significant 2-way interaction of time × body dimension revealed that after being exposed to slim bodies both groups showed a decrease of the ideal BDS% with respect to the baseline (pre: 14.54 ± 1.11 vs. post: 13.23 ± 1.04, $p = 0.026$), while no effects were observed for the other body dimensions (all $p_s > 0.389$). This effect was comparable in both groups since no significant 3-way interaction of time × body dimension × group was found [$F_{(3,72)} = 0.445$; $p = 0.722$; $\eta p^2 = 0.018$] (see Figure 4B).

Control Exposure

The 3-way ANOVA on esthetic judgments revealed significant main effects of group, size and time [all $F_{(1,24)} > 5.764$; $p < 0.024$; $\eta p^2 > 0.194$], with greater esthetic judgments provided by controls than by patients, for slim than round bodies, and in the post- than pre-exposure condition. However, no 2- or 3-way interactions did reach the significance

threshold [all $F_{(1,24)}$ < 0.766; p > 0.390; ηp^2 < 0.031], suggesting that the control exposure had no effect on the esthetic VAS judgments of thin and round models in either patients or controls (see Figure 3C).

The 3-way ANOVA on BDS% revealed no significant main effects of group, time and body dimension [all Fs < 2.249; p > 0.147; ηp^2 < 0.086]. Furthermore, no 2- or 3-way interactions between group, time and body dimension did reach the significance threshold [all $F_{(1,24)}$ < 1.001; p > 0.327; ηp^2 < 0.040], suggesting that the control exposure had no effect on the BDS% of perceptual, metacognitive, felt and ideal body images in either patients or controls (see Figure 4C).

Please insert Figure 3 almost here

Please insert Figure 4 almost here

Duration of exposure effects

The 3-way ANOVA on the ECJ after round exposures revealed significant a main effect of size [$F_{(1,24)}$ > 4.784; p = 0.039; ηp^2 = 0.166], which was further qualified by the significant 2-way interaction of size × group [$F_{(1,24)}$ = 6.898; p = 0.015; ηp^2 = 0.223]. Post-hoc comparisons confirmed the results of the main analysis by showing that the AN patients' EJC after exposure to round models was not different for round and thin bodies (Round: 3.422 ± 0.84; Thin: 3.989 ± 1.717; p = 0.759). Conversely, in controls, the EJC for round bodies was significantly higher than the one for thin bodies (Round: 5.104 ± 0.84; Thin: -1.118 ± 1.717; p = 0.012). This effect derived from higher ECJ for thin bodies in AN patients than in controls (p = 0.027). Importantly, no 2- or 3-way interactions involving block and size did reach the significance threshold [all $F_{(1,24)}$ < 2.822; p > 0.069; ηp^2 < 0.105]. No significant effects were obtained from the ANOVAs for the thin and control exposures [all $F_{(1,24)}$ < 3.091; p > 0.055; ηp^2 < 0.114]. Thus, the

effects of round exposure remained constant during the 10-min duration of the evaluation procedure both in patients and in controls, while no effects were obtained after thin a control exposures independently from the time elapsed since the exposure phase.

Correlational Analysis

The correlation analysis showed that the individual EJC for slim models after round exposure was significantly correlated with the individual scores at the EDI-2 DT scale in AN patients ($r = 0.622$, $p = 0.023$) but not in controls ($r = 0.255$, $p = 0.4$) (See Figure 5). Thus, AN patients with excessive concern with dieting were more prone to change their esthetic judgments of slim models after round exposure. No other correlation reached significance in any group (- $0.162 <$ all $r < 0.548$). Furthermore, no significant correlations were found between the individual BDSC% of the 'perceptual body dimension' after round exposure and the individual scores at the EDI-2 DT and BD' subscales (- $0.287 <$ all $r < 0.386$).

Finally, we also controlled whether the changes of esthetic judgments after round exposure were associated with changes in the absolute level of body distortion in each body dimensions. Interestingly, we found a correlation between the individual EJC for thin models and the individual BDSC% of the 'ideal body dimension' after exposure to round models in AN patients ($r = 0.579$, $p = 0.038$) but not in healthy controls ($r = 0.039$, $p = 0.899$). Therefore, the AN patients that were more prone to change their esthetic judgments of thin models after round exposure, also showed higher change of ideal self-body image after being exposed to round models.

Please insert Figure 5 almost here

Discussion

In the present study we investigated how women suffering from AN are affected, as compared to controls, by perceptual adaptation to thin and round body shapes and, in particular, whether brief exposures to extreme weight figures change not only the esthetic appreciation of unfamiliar bodies (Task 1), but also the different dimensions of self-body image (Task 2). In addition, since BD and DT affect esthetic perceptions of body norms and ideals (Glauert et al. 2009), we examined the relationship between these self-report ED psychopathology measures with the effects of exposure to thin and round bodies in AN patients and controls.

The results of the esthetic task showed that exposure to round models exerted a different modulation of the esthetic judgments of bodies in AN patients and in controls. **Furthermore, these effects were comparable for female and male models, suggesting that body perceptual after-effects are related to basic aspects of body perception (i.e. shape) and are not only limited to the processing of body figures similar to the patients' body.** In keeping with the results on healthy adults (Mele et al. 2013) and adolescents (Mele et al. submitted), thin bodies always received largely higher liking judgments than round bodies in all conditions. **However, only in AN patients, compared to controls, brief amounts of exposure to round bodies significantly altered the strong appreciation of thin bodies. On the contrary, round bodies received higher liking VAS after round exposure both for AN patients and for controls**. This finding is in keeping with previous results on adolescent patients with AN (Mele et al. submitted) and suggests that altered sensitivity of esthetic appreciation system to perceptual experience characterizes AN clinical profile across different patients' age (present study vs. Mele et al. submitted; 26.9 vs.15.5 years), illness onset age (18.6 vs. 13.5 years) and illness duration (8.3 vs. 2.2).

Crucially, the altered effects of perceptual adaptation to round bodies in AN patients also extended to the perceptual and ideal dimensions of self-body image. Indeed, the

self-body distortion task revealed that AN patients showed, after exposure to round models, an increased distortion for the perceptual component of self-body image, with patients reporting greater distortion values in reference to their actual size. **On the other hand, finding indicated a trend toward significance for the 'ideal' component 'How would you like to appear?', with patients showing decreased distortion in reference to their actual size.** To the opposite, both perceptual and ideal components of self body image remained unchanged after exposure to round bodies in control participants. Thus, patients with AN, but not controls, liked more thin bodies after exposure to round bodies, and changed their distorted perception of their actual and ideal body image. The distortion for the ideal component of both AN patients and controls decreased after exposure to thin bodies, while neither the perceptual component of self-body image nor the esthetic appreciation of others' bodies were affected.

Crucially, we found that the AN patients who showed higher increase of the esthetic appreciation of thin bodies after round exposure also had higher DT and tended to reduce more the distortion of the ideal self-body image after round exposure. Thus, the present study allowed us to document a specific relation between the altered esthetic sensitivity of AN patients to the effects of perceptual exposure to round bodies, their body image concerns (in particular drive for thinness) and changes of self-body image.

According to perceptual after-effects the repeated exposure to stimuli with given features changes the subsequent perception in the direction opposite to the adapted features (Thompson and Burr 2009). Therefore, although we did not directly control for the perceptual effects of exposure on unfamiliar body size estimation, perceptual after-effects predict that both round and thin bodies should be perceived as thinner after exposure to round models and this should increase their esthetic ratings. **However, this perceptual mechanism might be compensated in healthy controls by a reshaping of the ideals of body beauty (Mele et al.**

2013). In keeping with this view, since round bodies are expected to become more familiar than thin bodies after exposure to round bodies, they should also become less likable, thus counteracting the increase of liking ratings for perceptual after-effects. In sum, the mutual effects of perceptual after-effects and norm-based coding may explain the increased ratings of round, but not thin bodies, in healthy controls after round exposure. Conversely, the increase of the esthetic ratings of both thin and round bodies after exposure to round models in AN patients is in line with the modification expected according to perceptual after-effects mechanisms devoid of any counteracting effect of norm-based reshaping.

The asymmetric strength of perceptual after-effects in AN patients may be reflected also in a greater distortion of perceived self-body image as estimated with the computer-assisted adjustment procedure. Indeed, the adjustment estimates depends on how the participant's picture is perceived; if it looks thinner after round exposure, patients will tend to adjust the self-body image at rounder versions to match it with their inner representation, thus increasing the distortion of the perceptual dimension. Conversely, just because the self-body pictures look thinner after round exposure, during the ideal body image task patients showed a trend to adjust it at less thinner versions after round exposure, because the image is closer to their ideal of body beauty, which has arguably remained unchanged by the exposure. In support of this perceptual explanation of the change of ideal self-body image after round exposure, the correlation analysis showed in AN patients a linear relationship between higher increase of thin bodies esthetic perception and lower distortion of ideal self-body image. These changes of perceptual and ideal self-body image adjustment results were not observed in healthy controls, since perceptual after-effects were compensated by the reshaping of the prototype-referenced template (and arguably of the ideal of body beauty), which may be used to perceive others' as well as self-body pictures.

The finding that only exposure to round but not thin bodies changed the esthetic appreciation of others' bodies as well as the perceptual body image in AN patients deserves discussion. This is concordant with some evidence that adaptation-like effects are seen only for larger but not for thin models' images (Boothroyd, Tovèe and Pollot 2012; Re et al. 2011). However, it partially contrasts with previous studies testing the effects of body size adaptation on body normality and esthetic ideals, at least in healthy participants. For instance, Winkler and Rhodes (2005) found that only exposure to thin, but not to round, bodies modulated attractiveness judgments in healthy women. Furthermore, Glauert and colleagues (2009) found that exposure to thin bodies had greater effect on women's perceptions of body normality than exposure to round bodies. Finally, in a former study on healthy participants, Mele et al. (2013) found an asymmetric modulation of both round and thin exposures on the esthetic appreciation of others' round, but not thin bodies. One possible explanation for the lack of adaptation to thin bodies is that the model body images used in the thin exposure condition may have been similar to those frequently shown by the media. Accordingly, women's preferences may have already been 'tuned' to thin ideals before adaptation, due to frequency and familiarity of such bodies in the media, thus nullifying the effect of further presentations.

Crucially, we also found that AN patients who endorse excessive concerns regarding weight and dieting were more prone to increase the esthetic appreciation of thin bodies after repeated presentation of round models. Therefore, the different sensitivity of AN patients vs. controls to body exposure may play an important etiological and maintenance role for the body image disturbances in AN. Conversely, neither in AN patients nor in controls did we find any relationship between the amount of esthetic rating changes of thin and round models after exposure and BD and internalization of Western ideals. This may be attributed to the limited range of scores in each group of AN patients and controls, which might have

potentially swamped the small individual differences within each group, despite the large difference between the two groups. Furthermore, BD may be associated to sensitivity to perceptual exposure when evaluated in a longer term (Hargreaves and Tiggemann 2003). However, the present study did not address the long-term cumulative effect of media exposure on the development of negative body image and other ED symptoms. Thus, future studies are needed to examine the relation between exposure duration and the extent of adaptation effects with regard to BD.

Limitations and Conclusion

Even though this study provides insightful evidence concerning the role of perceptual exposure in the cognitive-affective and esthetic dimensions of body image, its limitations must be kept in mind when interpreting the results. First of all, we cannot establish whether the alteration of exposure effects in AN patients are specific for bodily stimuli or might also extend to faces or to other non-bodily objects. Indeed, a previous study (Glauert et al. 2009) has shown that exposure to a non-corporeal object (i.e. a coke bottle altered in size to appear thinner or rounder) symmetrically modulated the normality judgments of similar objects, with the adapted object figure being evaluated as more normal. However, while these effects were similar to those obtained with thin and round body stimuli, psychological dimensions such as BD and internalization of the Western ideal body of the participants were related only to the effects of the body exposure, but not to those of the object exposure. This suggests that the effects of body exposure may have a clinical relevance for the onset and maintenance of body image disturbances, while those of the exposure to other objects do not. Furthermore, a study of Ghuman et al. (2010) reported cross-category adaptation after-effects only within person perception, demonstrating that prolonged viewing of a human body, but not of connotative objects and shoes, shifts the perceptual tuning curve for face gender and face identity. Similarly, a study of Re and colleagues (2011) reported body to face after-effects with

participants preferring faces higher in facial adiposity after adaptation to heavy bodies. Thus adaptation to one body aspect may affect preferences in other aspects, but these effects seem to be specific for the domain of the human body.

Interestingly, we found that that the gender of the virtual bodies did not interact with the effects of exposure neither with the group factor. Although, we acknowledge that our study was not particularly designed to test for gender-specific exposure effects, this finding may suggest that body exposure effects are related to basic aspects of body perception (i.e. shape) and are not only limited to the processing of body figures similar to the patients' body. For future research it would be interesting to test whether and to what extent the model and participant' gender interact during body exposure.

Furthermore, we cannot ascertain whether AN patients' cognitive-affective and esthetic judgments have been driven by systematic difference in scanning pattern and fixation towards local details with respect to global configuration of the bodies. Interestingly, a recent study (Urgesi et al. 2012) documented better visual discrimination performance of AN patients vs. controls in the processing of body morphology but not of body actions. This paradoxical advantage in processing body parts observed in the AN patients is in keeping with their deficits of configural body processing (Urgesi et al. 2014), which may in turn reflect the general attention to details observed in AN patients (Suchan et al. 2013). Therefore, future studies using eye movement tracking are needed to investigate the role of looking behavior and attentional bias in the altered sensitivity to models of body beauty in AN patients. **It would also be helpful to replicate our findings using real picture stimuli with known BMIs (Glauert et al. 2010), seen that this would allow for a direct control of how the observer's BMI may influence esthetic body appreciation and body exposure effects. Most importantly, the use of adaptation photographs of real bodies and with less**

extreme size figures would provide additional information of the generalizability of the exposure related-effects in real life.

Finally, an important limitation regards the small sample size of this study, which may limit the generalizability of the findings to the general population of AN patients. However, the fact that we replicated in both AN patients and controls the pattern of modification of esthetic judgments obtained in previous body exposure studies (Mele et al. 2013; Mele et al. submitted) may reassure on the reliability of the results. In fact, the replication of comparable changes of body esthetic appreciation in (still small) groups of patients of different ages, with different levels of illness chronicity and with different comorbidities may unravel a common pattern of perceptual alterations that may make patients more susceptible to develop an ED.

In conclusion, the present study documented that the way in which AN patients' perception of their own and others' body is influenced by exposure to round figures is altered as compared to that of controls. Furthermore, these aberrant exposure effects seem to be associated with patients' greater preoccupation with dieting. Taken together, the results suggest that the construct of body esthetic ideals in AN patients is easily malleable and repeated exposure to round bodies may aggravate not only the alterations of the esthetic appreciation of others' bodies, but also the perceptual distortions of self-body image. Therefore, our current findings bring about the importance of perceptual adaptation alterations in ED psychopathology. Furthermore, in conjunction with those of previous research (Eshkevari et al. 2012), they may provide support for the view that body-specific visual hypersensitivity, rather than general sensory or visual processing problems, may affect the plasticity of body image in AN (Urgesi et al. 2014). If alterations of the mechanisms involved in the shaping of beauty appreciation after perceptual experiences act as a maintaining factor in AN pathology, it would be worthwhile to investigate in future research which are the most optimal

body figures to be used in body exposure interventions with AN patients, taking into account their specificity as compared to general population of women that do not develop an ED even being immersed in the same socio-cultural environment. Future studies with larger samples and more ecological conditions as compared to this laboratory-set experiment are required however to confirm the generalizability of the findings.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

Ahern AL, Bennett KM, Hetherington MM (2008) Internalization of the ultra-thin ideal: Positive implicit associations with underweight fashion models are associated with drive for thinness in young women. Eat Disord: J Treat Prev 16:294-307.

American Psychiatric Association. DSM-IV-TR: Diagnostic and Statistical Manual of Mental Disorder, 4rd Edition - Text revision. Washington, DC: American Psychiatric Press Inc; 1994, p. 980.

Boothroyd LG, Tovée MT, Pollett T (2012) Visual Diet versus Associative Learning as Mechanisms of Change in Body Size Preferences. PLoS One 7(11): e48691.

Calder AJ, Beaver JD, Winston JS, Dolan RJ, Jenkins R, Eger, E et al (2007) Separate coding of different gaze directions in the superior temporal sulcus and inferior parietal lobule. Curr Biol 17:20–25.

Cattarin JA, Thompson JK, Thomas C, Williams R (2000) Body image, mood and televised images of attractiveness: The role of social comparison. J Soc Clin Psychol 19:220–239.

Cazzato V, Mele S, Urgesi C (2014) Gender differences in the visual underpinning of perceiving and appreciating the beauty of the body. Behav Brain Res 264:188–196.

Cazzato V, Mian E, Serino A, Mele S, Urgesi C (2015) Distinct contributions of extrastriate body area and temporoparietal junction in perceiving one's own and others' body. Cogn Affect Behav Neurosci 15:211-228.

Cazzato V, Siega S, Urgesi C (2012) "What women like": influence of motion and form on esthetic body perception. Front Psychol 3:235.

Cooper PJ, Taylor MMJ, Cooper Z, Fairbum CG (1987) The development and validation of the body shape questionnaire. Int J Eat Disord 6:485–494.

Dennett HW, McKone E, Edwards M, Susilo T (2012) Face aftereffects predict individual differences in face recognition ability. Psychol Sci 23:1279-1287.

Derogatis LR, Lipman RS, Covi L (1973) SCL-90: an outpatient psychiatric rating scale-preliminary report. Psychopharmacol Bull 9:13-28.

Dittmar H, Howard S (2004) Thin-Ideal internalization and social comparison tendency as moderators of thin media models' impact on women's body focused anxiety. J Soc Clin Psychol 23:768–791.

Dobson KS, Dozois, DJA (2004) Attentional biases in eating disorders: A meta-analytic review of Stroop performance. Clin Psychol Rev 23:1001–1022.

Durkin SJ, Paxton SJ (2002) Predictors of vulnerability to reduced body image satisfaction and psychological well-being in response to idealized female media images in adolescent girls. J Psychosom Res 53:995–1005.

Eshkevari E, Rieger E, Longo MR, Haggard P, Treasure J (2012) Increased plasticity of the bodily self in eating disorders. Psychol Med 42:819-828.

Fernandez S, Pritchard M (2012) Relationships between self-esteem, media influence and drive for thinness. Eat Behav 13:321-325.

Fox CJ, Barton JJS (2007) What is adapted in face adaptation? The neural representations of expression in the human visual system. Brain Res 1127:80–89.

Garner DM, Olmstead MP, Polivy J (1983) Development and validation of a multidimensional eating disorder inventory for anorexia nervosa and bulimia. Int J Eat Disord 2:15-34.

Garner, D.Eating Disorder Inventory, 2. Firenze, Italy: Organizzazioni Speciali; 1984.

Ghuman AS, McDaniel JR, Martin A (2010) Face adaptation without a face. Curr Biol 20:32-36.

Gibson JJ, Radner M (1937) Adaptation after-effect and contrast in the perception of tilted lines. J Exp Psychol 20:453–467.

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

Glauert R, Rhodes G, Fink B, Grammer K (2010) Body dissatisfaction and attentional bias to thin bodies. Int J Eat Disord 43:42-49.

Hargreaves D, Tiggemann M (2003) Longer-Term Implications of Responsiveness to 'Thin-Ideal' Television: Support for a Cumulative Hypothesis of Body Image Disturbance? Eur Eat Disord Rev 11:465-477.

Hargreaves D, Tiggemann M (2003) The effect of "thin ideal" television commercials on body dissatisfaction and schema activation during early adolescence. J Youth Adolesc 32:367–373.

Hausenblas HA, Campbell A, Menzel JE, Doughty J, Levine M, Thompson JK (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.

Hummel D, Rudolf AK, Untch KH, Grabhorn R, Mohr HM (2012) Visual adaptation to thin and fat bodies transfers across identity. PLoS One 7(8):e43195.

Johnson, F., Wardle, J (2005) Dietary restraint, body dissatisfaction, and psychological distress: A prospective analysis. J Abnor Psychol 114:119–124.

McCollough C. (1965) The conditioning of color-perception. Am J Psychol 78:362–78.

Mele S, Cazzato V, Urgesi C (2013) The importance of perceptual experience in the esthetic appreciation of the body. PLoS One 8(12):e81378.

Mele S, Di Taranto F, Cazzato V, Maestro S, Fabbro F, Muratori F, Urgesi C. Altered norm-based reshaping of esthetic body ideals in adolescent patients with Anorexia Nervosa. Unpublished Results.

Mian E, Gerbino W (2009) Body image assessment in the computer aided psychological support for eating disorders. Abstracts from cyber therapy 14, designing the future of healthcare, Lago Maggiore, Verbania, Italy. Cyber Psych Behavior 12:581–673.

Ng M, Boynton GM, Fine I (2008) Face adaptation does not improve performance on search or discrimination tasks. J Vis 8:1–20.

Palumbo R, D'Ascenzo S, Tommasi L (2015) Cross-category adaptation: exposure to faces produces gender aftereffects in body perception. Psychol Res 79:380-388.

Palumbo R, Laeng B, Tommasi L (2013) Gender-specific aftereffects following adaptation to silhouettes of human bodies. Visual Cognition 21:1-12.

Probst M, Vandereycken W, Van Coppenolle H, Vanderlinden J (1995) The body attitude test for patients with an eating disorder: Psychometric characteristics of a new questionnaire. Eat Disord 3:133–144.

Re DE, Coetzee V, Xiao DK, Buls D, Tiddeman BP, Boothroyd LG, Perrett DI (2011) Viewing heavy bodies enhances preferences for facial adiposity. J Evol Psychol 9:295–308.

Rhodes G, Jeffery L, Watson TL, Clifford CW, Nakayama K (2003) Fitting the mind to the world: face adaptation and attractiveness aftereffects. Psychol Sci 14:558-566.

Smeets MAM, Klugkist IG, van Rooden S, Anema HA, Postma A (2009) Mental body distance comparison: A tool for assessing clinical disturbances in visual body image. Acta Psychol 132:157–165.

Smeets MAM, Kosslyn SM (2001) Hemispheric differences in body image in anorexia nervosa. Int J Eat Disord 29:409–416.

Stefanile C, Matera C, Nerini A, Pisani E (2011) Validation of an Italian version of the sociocultural Attitudes Towards Appearance Questionnaire-3 (SATAQ-3) on adolescent girls. Body Image 8:432–436.

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.

Stice E, Ng J, Shaw H (2010) Risk factors and prodromal eating pathology. J Child Psychol Psych 51:518–525.

Suchan B, Bauser DS, Busch M, Schulte D, Grönemeyer D, Herpertz S, Vocks S (2013) Reduced connectivity between the left fusiform body area and the extrastriate body area in anorexia nervosa is associated with body image distortion. Behav Brain Res 241:80–85.

Thompson JK, van den Berg P, Roehrig M, Guarda AS, Heinberg LS (2004) The Sociocultural Attitudes Towards Appearance Scale-3 (SATAQ-3): Development and validation. Int J Eat Disord 35:293–304.

Thompson P, Burr D (2009) Visual aftereffects. Curr Biol 19:R11–4.

Thompson, JK (2004) The (mis)measurement of body image: Ten strategies to improve assessment for applied and research purposes. Body Image 1:7–14.

Tucci S, Peters J (2008) Media influences on body dissatisfaction in female students. Psicothema 20:521-524.

Urgesi C, Fornasari L, Canalaz F, Perini L, Cremaschi S, Faleschini L, Zappoli Thyrion E, Zuliani M, Balestrieri M, Fabbro F, Brambilla P (2014) Impaired configural body processing in anorexia nervosa: Evidence from the body inversion effect. Br J Psychol 105:486-508.

Urgesi C, Fornasari L, Perini L, Canalaz F, Cremaschi S, Faleschini L, Balestrieri M, Fabbro, F, Aglioti SM, Brambilla P (2012) Visual body perception in anorexia nervosa. Int J Eat Disord. 45: 501–511.

Valentine T, Darling S, Donnelly M (2004) Why are average faces attractive? The effect of view and averageness on the attractiveness of female faces. Psychon Bull Rev 11:482-7.

Valentine T. Representation and process in face recognition. In J. Cronley-Dillon (Series ed.) & R. J. Watt (Vol. ed.) Pattern recognition by man and machine: Vol. 14. Vision and visual dysfunction. Basingstoke: Macmillan. 1991, pp. 107-124.

Webster MA, Kaping D, Mizokami Y, Duhamel P (2004) Adaptation to natural facial categories. Nature 428:557–61.

Wiederman MW, Pryor TL (2000) Body dissatisfaction, bulimia, and depression among women: the mediating role of drive for thinness. Int J Eating Disord 27:90–95.

Winkler C, Rhodes G (2005) Perceptual adaptation affects attractiveness of female bodies Brit J Psychol 96:141–54.

Figures Captions:

Figure 1: Example of distorted (from round to thin) stimuli of the pre- and post-exposure evaluation trial during the esthetic task.

Figure 2: Examples of distorted (from round to thin) pictures of a person during the self-body distortion task.

Figure 3: Mean (± s.e.m.) scores (in mm) of the visual analogue scale (VAS) of patients with Anorexia Nervosa (AN) and controls before and after the round (A), slim (B) and control (C) exposures. Asterisks indicate significant pairwise comparisons.

Figure 4: Mean (± s.e.m.) scores on BDS % scores (calculated as the absolute difference from the 0%, non-distorted level) of patients with Anorexia Nervosa (AN) and controls before and after the round (A), slim (B) and control (C) exposures and as a function of the different body dimensions (perceptual, metacognitive, felt, ideal). Asterisks indicate significant pairwise comparisons.

Figure 5: Multiple scatter plot of perceptual aftereffect in round condition for slim models as measured by the esthetic judgment change (Post- minus Pre-exposure) vs. the Drive for Thinness EDI-2 scale. Black and white circles represent AN patients and controls, respectively.