Body Dissatisfaction and Self-Disgust as Significant Predictors of Body-Related Attentional Bias. A Virtual Reality and Eye-Tracking Study

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Abstract. Body dissatisfaction, fear of gaining weight (FGW) and body anxiety have been extensively studied as some of the strongest risk and maintenance factors of anorexia nervosa (AN) symptomatology. Recently, a new theoretical model introduced self-disgust as a factor that can lead to avoidance behaviors when patients with AN face their body. This can make them vulnerable to relapse. In addition, body-related attentional bias (AB) (e.g., selective attention to weight-related body areas) can limit the efficacy of body exposure therapies. This study aims to investigate the possible predictors of AB, to better understand the underlying mechanisms that contribute to the maintenance of AN symptomatology. A total of 116 college students from the University of Barcelona participated in the study, using a combination of virtual reality and eye-tracking techniques to provide an objective and reliable assessment of AB in a highly realistic environment. Stepwise multiple linear regression analyses were performed to identify possible predictors of AB among body mass index, FGW, body anxiety, body dissatisfaction and self-disgust. The results shows that both body dissatisfaction and self-disgust are significant predictors of AB. While an increase in body dissatisfaction predicted a greater AB towards weight-related body areas (positive regression coefficients: $B_{Body\_dissatisfaction \rightarrow AB} > 0$, $p < .001$), the opposite occurred with self-disgust (negative regression coefficients: $B_{Self\_disgust \rightarrow AB} < 0$, $p < .02$). Such results provide initial evidence that self-disgust, which is a more intense negative feeling than body dissatisfaction, leads to gaze avoidance towards weight-related body areas, which are considered disgust elicitors.

Keywords: anorexia nervosa, attentional bias, body dissatisfaction, self-disgust, virtual reality, eye-tracking

1. Introduction

Anorexia nervosa (AN) is an eating disorder (ED) characterized by low weight (less than 85% of what is expected considering age and height), body image disturbances (BID; i.e., a dysfunctional way that individuals experience their body weight and shape) and an extreme fear of gaining weight (FGW). AN is considered one of the most serious ED and presents high comorbidity with other disorders, especially anxiety, depressive and

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personality disorders, and a multitude of medical complications derived from the state of malnutrition [1]. Previous studies showed that FGW and body anxiety towards specific own body areas (i.e., the body parts that the individuals may relate to weight) were some of the strongest risk and maintenance factors of AN symptomatology, which are also related to more severe ED symptoms [2]. Moreover, body dissatisfaction (i.e., the affective component of BID) causes a series of avoidance behaviors and negative checking strategies towards one's own body [3]. It has been shown to be a significant predictor of anorexia readiness syndrome (ARS) in women [4], and a predictor of a perceptual body distortion in the allocentric perspective (e.g., from third-person view), referring to external body benchmarks constructed by inter-individual comparison, influenced by abstract knowledge, beliefs, and attitudes related to a person's body in a given cultural context [5,6]. In addition, in a theoretical model recently proposed by Glashouwer & de Jong (2021) [7], self-disgust (i.e., intense negative feelings of revulsion and an overwhelming and irresistible urge to avoid potential disgust elicitors) could lead to avoidance behaviors when patients with AN face their body (e.g., hiding their body in wide clothing, not touching their body, or taking a shower with the lights turned off). This can make individuals vulnerable to relapse.

Body exposure therapies have been used to reduce the effects of these factors through habituation process [8] but can be limited due to body-related attentional bias (AB) (e.g., selective attention towards specific body areas). Previous studies described this AB as a tendency to focus more on self-reported unattractive body parts than other body parts in adult women with high body dissatisfaction (e.g., [9]) and patients with ED (e.g., [10]). In addition, body-related AB has been shown to be an important risk factor for maintaining BID and associated mental health concerns in healthy individuals and patients with EDs (see the full review in [11]). Previous studies have used virtual reality (VR), in combination with eye-tracking (ET) techniques, to assess the effects of body-related AB and enhance body exposure therapies for the treatment of ED (full reviews available in [12,13]). Indeed, the integrated ET feature in the VR head-mounted display (HMD) provides a direct, continuous, objective assessment of attentional patterns in real-time. It highlights avoidance and engagement with stimuli over time (e.g., with food cues or the participants' specific body parts) [14]. In addition, using VR technology, researchers and therapists can create highly realistic simulations of real-life settings and situations that individuals have associated with their body and weight concerns (e.g., a dressing room, a bathroom or a locker room), and design three-dimensional (3D) avatars that reproduce the patients' silhouettes based on their own body size, height, skin tone and clothes [15]. In addition, the full-body motion tracking feature of VR systems enables synchronization of movements of individuals and avatars, so that participants can perceive and feel their respective virtual bodies as if they were their real bodies by activating the feeling of ownership over a virtual avatar [16]. This paradigm is known as the full-body ownership illusion [17]. For these reasons, VR is considered a transformative technology that is now used in various fields of psychology, both in research and therapeutics (see full reviews in [18,19]).

This study aims to use a combination of VR and ET techniques to assess the body-related AB of participants, while looking at their avatars in a virtual mirror (e.g., from an allocentric perspective), to search for possible predictors of AB among variables related to AN (i.e., body mass index [BMI], FGW, body anxiety, body dissatisfaction and self-disgust) and thus better understand the underlying mechanisms that contribute to the maintenance of AN symptomatology.

2. Method

2.1 Participants

College students from the Faculty of Psychology of the University of Barcelona were recruited using social networks and flyers. Finally, 116 students (99 females, 17 males, M_{age} = 24.43 years, SD_{age} = 5.30 years; M_{BMI} = 22.52 kg/m^2, SD_{BMI} = 2.99 kg/m^2)

participated voluntarily in the study and went through the entire procedure. The exclusion criteria were self-reported diagnosis of ED or mental disorders with psychotic or manic symptoms (e.g., psychotic disorders or bipolar disorders), pregnancy (which could temporarily distort the body image), epilepsy and visual conditions (e.g., severe astigmatism that could distort eye-tracking measures).

2.2 Instruments

A VR environment was developed using Unity 3D 5.6.1. software. It consisted of a room without any furniture except for a large mirror located 1.54 m in front of the participant and two boxes placed on the floor beside him/her (see Figure 1). The participant was immersed in a VR-environment using a HMD HTC VIVE Pro Eye®, which integrates dual-OLED displays (combined resolution of 2880 x 1600 pixels and 615 PPI) and an ET feature powered by Tobii® with very high precision (binocular gaze data output frequency: 120 Hz, spatial accuracy between 0.5 and 1.1 degrees, 5-point calibration process). The virtual body reflected in the mirror was an avatar, designed using Blender® v2.78 and adjusted finely to each participant's height and silhouette through an initial photography procedure. The avatar wore standard clothes (including t-shirt, trousers and shoes), whose colors could be adjusted to that of the participant. In addition, the avatar wore a HMD and its head was covered by a grey cap, to reproduce the actual participant's condition during the task and reduce the influence of individual hairstyle.

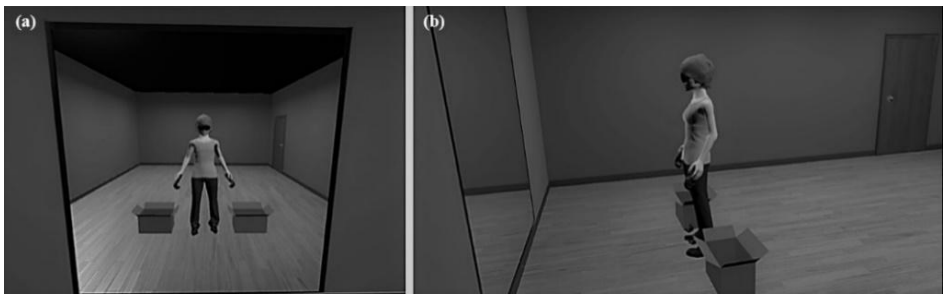

Figure 1. Front (a) and profile (b) views of female avatar in the VR immersive environment.

2.3 Measures

BMI was calculated after measuring the participant's weight and height on-site, using the formula BMI = weight (in kilograms)/ height (in m)^2. Body dissatisfaction was assessed through the Spanish version [20] of the 10-item EDI-BD subscale of EDI-3 inventory [21], which measures body dissatisfaction with the whole body and specific body parts. EDI-3 has robust validity indices, temporal stability and good internal consistency (Cronbach's alpha between .74 and .96) [20]. Self-disgust was assessed using the 12-item Self-Disgust Scale (SDS) [22], which shows good psychometric qualities in terms of internal consistency (Cronbach's alpha = .91), reliability (significant test-retest correlation of .94) and convergent validity [22]. In the current study, Cronbach's alphas were .85 for the EDI-BD scale and .88 for SDS. FGW and body anxiety were assessed through visual analog scales (VAS) from 0 to 100 with the following questions, respectively: "on a scale of 0 to 100, indicate to what extent you are afraid of gaining weight at this moment, where 0 is not at all and 100 is a lot", "on a scale of 0 to 100, indicate the level of anxiety toward your body that you are feeling at this moment, where 0 is not at all and 100 is a lot".

AB was assessed through a similar procedure to that used in a previous study (see the full description in [23]), based on the participants' visual fixations of more than 100 ms on specific body areas of interest (AOIs), recorded through the ET feature of the

HMD and then processed by OGAMA software (Freie Universität, Berlin, Germany). Such a specific gaze-behavioral measure has been shown to be a reliable measure of attention allocation towards specific body areas in previous studies using ET techniques (see full reviews in [12,24]).

Two groups of AOIs were defined based on the Physical Appearance State and Trait Anxiety Scale (PASTAS; [25]) and labelled as follows (see Figure 2a):

- Weight-related AOIs (W-AOIs): thighs, buttocks, hips, stomach, legs and waist.
- Non-weight-related AOIs (NW-AOIs): neck, chest, shoulders, arms and feet.

The head and hands of the participants were not considered in the calculation, since the avatars reflected in the mirror held VR devices (HMD and controllers) like the participants. In this case, fixations on these body parts had more to do with the attention towards these devices than with the participants' head and hands, and therefore could have biased the assessment of AB.

AB was assessed using complete fixation time (AB_CFT) and number of fixations (AB_NF), which were respectively defined as the difference between visual fixation duration (in ms) and number of fixations on W-AOIs minus those on NW-AOIs:

$$\text{AB\_CFT} = \text{Complete fixation time}_{\text{on W-AOIs}} - \text{Complete fixation time on}_{\text{NW-AOIs}} \quad (1)$$

$$\text{AB\_NF} = \text{Number of fixations}_{\text{on W-AOIs}} - \text{Number of fixations on}_{\text{NW-AOI}} \quad (2)$$

Both AB_CFT and AB_NF could thus adopt positive or negative values, depending on whether the participants' visual attention was predominantly focused on W-AOIs (positive values) or NW-AOIs (negative values) (see the examples of attentional patterns of both types in Figures 2b and 2c).

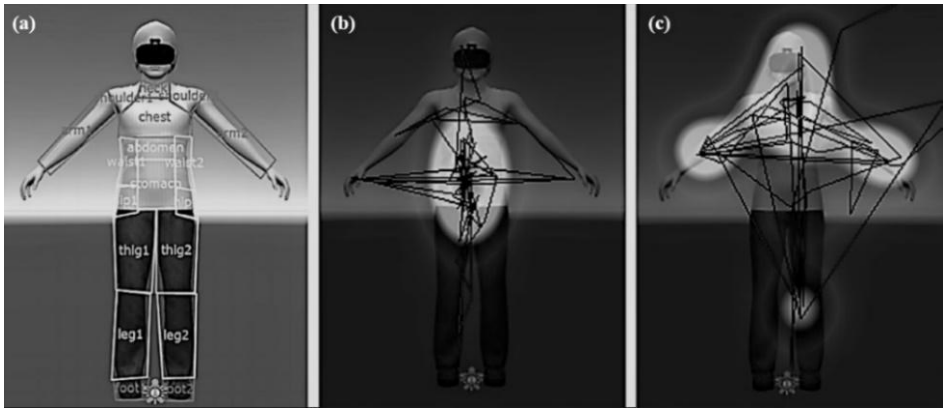

Figure 2. W-AOIs and NW-AOIs definition in OGAMA (a); examples of attentional patterns more focused on W-AOIs (AB_CFT > 0 and AB_NF > 0) (b), and on NW-AOIs (AB_CFT < 0 and AB_NF < 0) (c).

2.4 Procedure

This study was approved by the Bioethics Commission of the University of Barcelona (CBUB). At the beginning of the study, participants freely signed a consent form. Weight and height were then measured to calculate the BMI. Afterwards, while participants were answering the questionnaires and VAS to assess body dissatisfaction, self-disgust, FGW and body anxiety, the researcher created the avatars' silhouettes using a photography procedure. Participants were then immersed in the virtual environment using HTC VIVE Pro Eye ® HMD and equipped with body trackers to enable the avatars to move in the same way as their real body. A five-minute visuo-motor and visuo-tactile stimulation adapted from previous studies (e.g., see [26]) was then applied to elicit the Full Body Ownership Illusion (i.e., to perceive and regard a virtual body as one's own real body). Subsequently, the body-related AB was assessed during a 30-second free exposure task to participants' avatars reflected in a mirror in the virtual environment (i.e., from

allocentric perspective). HMD and body trackers were then removed, and the participants could rest for the necessary time, while the researcher answered any possible doubts.

2.5. Statistical analysis

Answers from EDI-BD and SDS questionnaires were processed using the Qualtrics® platform. In addition, ET data were imported into OGAMA software to process AB variables (AB_CFT and AB_NF). Then, stepwise multiple linear regression analyses were performed using IBM ® SPSS version 27 to identify possible predictors of AB (for both AB_CFT and AB_NF variables analyzed separately).

3. Results

Descriptive statistics for the entire sample are given in Table 1.

Table 1. Descriptive statistics for the entire sample. BMI = body mass index; AB_CFT and AB_NF = attentional bias (complete fixation time and number of fixations respectively); EDI-BD = body dissatisfaction scale; SDS = self-disgust scale; VAS_FGW = fear of gaining weight's VAS; VAS_BA = body anxiety's VAS.

	BMI	**AB_CFT (s)**	**AB_NF**	**EDI_BD**	**SDS**	**VAS_FGW**	**VAS_BA**
Mean	22.52	- 1.74	- 6.11	8.78	27.04	46.37	18.54
(SD)	(2.99)	(6.27)	(15.10)	(7.19)	(10.54)	(31.73)	(22.93)

All the linear regression's assumptions were satisfied. Linear relationships among the variables were apparent using scatter plots. There was homoscedasticity of the residuals (uniform variation of the residuals with predicted values as indicated by non-significant Pearson correlation; $p > .05$ for all variables) and normality of the residuals (as indicated by non-significant bilateral asymptotic significance in the Kolmogorov-Smirnof test; $p > .05$ for all variables). There was no multicollinearity between considered variables (tolerance > .1 and VIF < 10 for all variables). Finally, there was independence of the residuals, as assessed by Durbin–Watson statistics (1.78 and 1.72 respectively for AB_CFT and AB_NF regressions). No outliers were detected.

Analyses showed that both body dissatisfaction and self-disgust predicted AB_CFT with respectively $B_{EDI\text{-}BD \rightarrow AB\_CFT} = .360$ ($p < .001$) and $B_{SDS \rightarrow AB\_CFT} = -.176$ ($p = .011$), in a model that accounted for 14.1% of the explained variability (significant linear relation confirmed by ANOVA: $p = .001$). Similarly, body dissatisfaction and self-disgust predicted AB_NF with respectively $B_{EDI\text{-}BD \rightarrow AB\_NF} = .914$ ($p < .001$) and $B_{SDS \rightarrow AB\_NF} = -.397$ ($p = .016$), in a model that accounted for 15.1% of the explained variability (significant linear relation confirmed by ANOVA: $p < .001$). None of the other variables (BMI, FGW and body anxiety) explained a significant additional variance percentage of AB_CFT or AB_NF, so they were not included in the respective regression equations.

4. Discussion

Body dissatisfaction and self-disgust have been shown to be significant predictors of AB. An increase in body dissatisfaction predicted a greater AB towards weight-related body areas (an increase of 1 point on the EDI-BD subscale increased the AB_CFT by .360 seconds and the AB_NF by .914 fixations). However, the opposite occurred with self-disgust (an increase of 1 point on the SDS scale decreased the AB_CFT by .176 seconds and the AB_NF by .397 fixations). These results confirm a significant positive relationship between body dissatisfaction and body-related AB, which is defined as a tendency to focus more on some body parts (e.g., weight-related body parts) than other body parts (e.g., non-weight-related body parts), as shown in previous studies with non-clinical participants with high body dissatisfaction (e.g., [9]) and clinical patients with ED (e.g., [10]). These results provide the first evidence that self-disgust, defined as a more intense negative feeling than body dissatisfaction, has an opposite effect on the AB

and leads to gaze avoidance towards weight-related body parts considered as disgust elicitors, as predicted in the theoretical model [7]. However, such results still need to be confirmed with AN patients in future studies, to explore whether variables such as FWG, body anxiety and BMI also predict AB in patients, unlike in healthy participants. In addition, some improvements to the VR environment (to make it more relevant in everyday life situations), or to the avatars (e.g., using 3D body scanning to better design the avatars), should be considered to enhance the ecological validity with clinical patients.

As a conclusion, this study shows how the combined use of virtual reality and eye-tracking technology offers new opportunities to assess body-related AB, to better understand the underlying mechanisms that contribute to the maintenance of AN symptomatology, and to enhance body exposure therapies and AN treatment.

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