The influence of gender and body dissatisfaction on body-related attentional bias. An Eye-Tracking and Virtual Reality study.

Bruno PORRAS-GARCIA[a], Marta FERRER-GARCÍA[a], Alexandra GHITA[a], Manuel MORENO[b], Laura LÓPEZ-JIMÉNEZ[a], Alba VALLVÉ-ROMEU[a], Eduardo SERRANO-TRONCOSO[c] & José GUTIÉRREZ-MALDONADO[a]

[a] Department of Clinical Psychology and Psychobiology, University of Barcelona

[b] Department of Cognition, Development and Education Psychology, University of Barcelona

[c] Child and Adolescent Psychiatry and Psychology Department, Hospital Sant Joan de Déu of Barcelona

Department of Clinical Psychology and Psychobiology. Department of Cognition, Development and Education Psychology. University of Barcelona, Passeig de la Vall d'Hebron, 171, 08035 Barcelona, Spain

E-Mail: brporras@ub.edu

E-Mail: martaferrerg@ub.edu

E-Mail: alexandraghita@ub.edu

E-Mail: avallveromeu@gmail.com

E-Mail: lauralopji21@gmail.com

E-Mail: manelsg@gmail.com

E-Mail: jgutierrezm@ub.edu

Child and Adolescent Psychiatry and Psychology Department. Hospital Sant Joan de Déu of Barcelona, Passeig Sant Joan de Déu 2, 08950, Esplugues de Llobregat, Spain.

E-Mail: eserrano@sjdhospitalbarcelona.org

- *Corresponding author:* José Gutiérrez Maldonado. Department of Personality, Assessment and Psychological Treatments University of Barcelona, Passeig de la Vall d'Hebron, 171, 08035 Barcelona, Spain. E-Mail: jgutierrezm@ub.edu

Conflict of interest: None of the authors of this paper have a financial arrangement or affiliation with any product or services used or discussed in this paper.

Number of words- Abstract: 250

Number of words- Manuscript (excluding abstract, references, tables or figures): 4661

Abstract

Objective: In the Attentional Bias (AB) phenomenon, Eating Disorder (ED) patients show a tendency to pay more attention to self-attributed unattractive body parts than to other body parts. However, little research has focused on gender differences in body-related attention, controlling for body dissatisfaction (BD). This study aimed to assess gender differences in AB toward specific weight- or non-weight-related body parts using a Virtual Reality-based embodiment technique and an eye-tracking AB assessment. **Method:** Forty-five women (23 with high BD and 22 with low BD) and 40 men (20 with high BD and 20 with low BD) were subsequently embodied in three virtual avatars, the first based on the participant's actual measurements, the second being larger than the participant, and the third being the same as the first avatar. The number of fixations and complete fixation time on weight-related Areas of Interest (W-AOIs) and non-weight-related Areas of Interest (NW-AOIs) were recorded for the three-assessment time/avatars. **Results:** The results showed a statistically significant interaction between gender and time for total fixation time and number of fixations ($p<.05$). BD levels did not significantly affect the results. Overall, women paid more attention to the W-AOIs than men, who in turn paid more attention to the NW-AOIs. Furthermore, preliminary evidence was found for an AB toward muscular-related AOIs among men. **Conclusions:** This study provides new information about gender differences and BD in gaze pattern behaviors. Future psychological ED assessments and treatments could take advantage of the possibilities of Virtual Reality while real-time AB is objectively measured.

Keywords: attentional bias; gender; body image; virtual reality; eye-tracking.

1. Introduction

Previous research suggests that Eating Disorder (ED) patients pay more attention to body-related information than to other sorts of information (Rodgers & DuBois, 2016). This phenomenon is known as Attentional Bias (AB) (Williamson, White, York-Crowe, & Stewart, 2004). Specifically, ED patients tend to over-evaluate their shape and weight (American Psychiatric Association, APA, 2013) by repeatedly checking and scrutinizing their weight-related body parts or their general appearance, suggesting the presence of dysfunctional body-related attention (Lee & Shafran, 2004). This behavior has also been found in healthy women (Haase, Mountford, & Waller, 2011) and men (Walker, Anderson, & Hildebrandt, 2009).

Other researchers have focused on studying the relationship between dysfunctional body-related attention and body dissatisfaction (BD). BD has been reported to comprise negative and dysfunctional cognitions and emotions (sadness, anger or disgust) related to the way in which individuals evaluate and feel their own body (Cash & Brown, 1987; Cash & Deagle, 1997; Grogan, 2016), and it may trigger significant avoidance or negative body checking strategies (Legenbauer, Thiemann, & Vocks, 2014). Additionally, BD has been found to be highly prevalent in young women and men in the American population (Fiske, Fallon, Blissmer, & Redding, 2014), and is one of the most important risk factors for the development and maintenance of ED pathology both in women (Stice, Ng, & Shaw, 2010; Stice, Gau, Rohde & Shaw, 2017) and in men (e.g., Blashill, 2011; Dakanalis et al., 2015).

Dysfunctional body-related attention presumably maintains BD by processing only body information that is consistent with dysfunctional cognitive schema content (such as, *I am getting a fatter belly*), while schema-inconsistent information is not equally noticed or processed, usually being visually neglected (Rodgers & DuBois, 2016; Tuschen-Caffier et al., 2015; Williamson et al., 2004).

Previous studies have suggested that women with ED, and individuals with high BD levels, tend to pay more attention to self-defined unattractive body areas, while healthy participants tend to show a more general scanning behavior, covering either the whole body or the most attractive body parts (Freeman et al., 1991; Jansen, Nederkoorn, & Mulkens, 2005; Kerr- Gaffney, Harrison, & Tchanturia, 2019; Rodgers & DuBois, 2016; Roefs et al., 2008; Tuschen-Caffier et al., 2015).

To date, most studies have assessed visual AB only in women, while little research has focused on gender differences in body-related attention. Previous research suggests that men and women show different ways of evaluating their appearance as a result of different body image concerns. Thus, while women tend to check weight-related body areas (e.g., the waist), men tend to check body areas associated with muscularity (e.g., the chest) (Alfano, Hildebrandt, Bannon, Walker, & Walton, 2011). Previous Eye-tracking (ET) studies that have assessed AB for specific body parts found that both men and women with a higher drive for thinness showed an AB toward weight-related body parts, when they were exposed to pictures of young, attractive men and women (Hewig et al., 2008). Similar results were found in weight-training men with high drive for thinness who show AB toward their most unattractive body parts, when they were exposed to pictures of their own body (Cordes, Vocks, Düsing, Bauer, & Waldorf, 2016). Even though ET technology has recently proved to be a useful tool for assessing body-related attention (Jiang & Vartanian, 2018; Smeets, Jansen, & Roefs, 2011; Tuschen-Caffier et al., 2015) it also presents some important limitations, such as the lack of external validity (Kredel, Vater, Klostermann, & Hossner, 2017). The use of Virtual Reality (VR) technology may help to overcome this drawback by adding ET devices into the head-mounted display (HMD). The combination of the two technologies allows the measurement of gaze patterns in real time, in an objective and accurate way, while the individual is fully immersed in a VR scenario that simulates real-life situations (Hans-Martin Lutz et al., 2017). Additionally, the use of VR-based embodiment techniques provides the chance to create a real-size 3D simulation of the body of the participants with their specific physical features (Gutiérrez-Maldonado, Ferrer-Garcia, Dakanalis, & Riva, 2018) and feel their artificial body as their own body, in a paradigm known as full body ownership illusion (Maselli & Slater, 2013).

In a recent pilot study, ET and VR technologies were used to assess gender differences in AB using a VR-based embodiment procedure in which participants initially owned a virtual body (VB) with their own body measurements, then a larger-size VB and a repetition of the first VB (Porras-Garcia et al., 2018). In this preliminary study, a second real-size VB condition was included in order to ensure that the anxiety that some participants might experience after owning a larger-size VB (Ferrer-Garcia et al., 2017) was reduced. The results showed that women paid significantly more attention to weight-related body parts than men. Interestingly, the greatest gender differences in body-related attention were found in the second real-size VB condition.

The aim of the current study was to provide further information about gender differences and BD in body-related attention using the same design but with a larger sample. Thus, eye-gaze behaviors toward specific weight or non-weight-related body parts were assessed in women and men with high vs low BD levels while owning virtual avatars with different body sizes.

Based on our previous research, it was expected that, regardless of the level of BD, women would spend more time looking at weight-related body parts than non-weight-related body parts, while men would show the opposite gaze behavior pattern, looking more at non-weight-related body parts. More specifically, it was expected to find the greatest gender differences on body-related attention at the second real-size VB. Additionally, it was expected that women with high BD would spend even more time looking at weight-related body parts than women with low BD, while men with high BD would spend more time looking at non-weight-related body parts than those with low BD, in all virtual avatars with different body sizes.

2. Method

2.1. Participants

Eighty-five college students from the University of Barcelona, comprising 45 women (M_{age} = 23.89, *SD* = 3.25, M_{BMI} =22.24, *SD* =2.92) and 40 men (M_{age} =25.51, *SD* =3.88, M_{BMI} =23.58, *SD*= 2.47), participated in the study. They were recruited through campus flyers and advertisements in social network groups. The exclusion criteria were a self-reported diagnosis of a current ED, a Body Mass Index (BMI) of less than 17 (moderate thinness) or more than 30 (obesity; according to the World Health Organization (2004)), or a self-reported current Severe Mental Disorder Diagnosis (e.g., schizophrenia or bipolar disorder).

2.2. Instruments

An HMD HTC-VIVE containing an ET device (Pupil Labs) was used in this experiment. Two pieces of software were used to develop the virtual simulations: Blender 2.78 v. to create the virtual avatars (male and female avatars) and Unity 3D 5.5.v to develop the object-oriented programming code and integrate the elements within a virtual environment. The virtual environment consisted of a small room with a large mirror placed on a wall 1.5 meters in front of the subject. This mirror was not visible at the beginning of the experiment (first-person perspective) and was activated only during the third-person perspective condition. Both male and female avatars wore a standard black t-shirt with black jeans, black trainers and a swimming cap to reduce the idiosyncratic influence of hairstyle on each participant (see Figure 1.1).

2.2.1. Visual selective attention measures.

In accordance with the Weight Scale body items of the Physical Appearance State and Trait Anxiety Scale questionnaire (PASTAS, Reed, Thompson, Brannick, & Sacoo, 1991), the same areas of interest (AOIs) were individually drawn onto a 2D frontal view picture of the female or male avatar and were labeled as weight-related body-parts (W-AOIs): i.e., thighs, buttocks, hips, stomach, legs, waist. Muscle tone was not included due to the inability to reproduce it. The remaining body areas were labeled as non-weight-related body parts (NW-AOIs): i.e., head, shoulders, arms, décolletage, neck and chest (Figure 1.1). The participant's visual fixation, defined as the visual act of sustaining one's gaze on a single location over a minimum duration (typically 100–200 ms) (Jacob & Karn, 2003), was estimated by the following variables:

- *Number of fixations on AOIs*: Number of available fixations on the specified area of interest group (weight-related AOIs or non-weight-related AOIs).
- *Complete fixation time on AOIs*: Sum of the fixation duration at the specified area of interest group (weight-related body-parts or non-weight-related AOIs) in milliseconds. In this study, the exact duration used to define a single fixation was 83ms.

2.2.2. Assessment of eating disorder-related attitudes:

- *Eating disorder inventory* (EDI-3; Garner, 2004). EDI-3 is a self-report questionnaire used to assess ED symptomatology. It includes 12 scales and 91 items with a 6-point Likert scale for each response, ranging from 0 (*never*) to 5 (*always*). In this study we only used the Body Dissatisfaction (EDI-BD) scale. The EDI-BD scale, with 10 items, measures BD regarding the whole body or specific body parts, with a possible range of scores from 0 to 4. This questionnaire presents robust validity indices, both in the original version as well as in the Spanish version, and good reliability, with a Cronbach Alpha that ranges from 0.74 to 0.96 (Elosua, López-Jáuregui & Sánchez-Sánchez, 2010). The Cronbach Alpha value for the BD scale in this study was .825.

2.3. Procedure

This study was approved by the ethics committee of the University of Barcelona. Before entering the study, participants sign an informed consent form that explained the confidentiality of the data and the aim of the entire process. The confidentiality of the data was also guaranteed by giving each subject a specific identification code. All participants completed the EDI-BD. Then, they were weighed and measured to calculate their BMI. Afterwards, a photo of the whole body of each participant was taken by the researchers, using a camera. All participants were placed in a fixed position 2 meters from the camera, in which they had to stand still with their arms slightly raised and legs slightly apart. Each participant's photo and virtual avatar were manually overlapped by adapting the different dimensions of the virtual avatar (e.g., arms, legs, hip, waist, chest, stomach, breast, shoulder…) to fit the silhouette of the participant. Finally, all participants were exposed to the VR scenario displayed with an HMD (HTC-VIVE).

Each participant was exposed to three virtual bodies: the first with the same body size as the participant (Real-size VB); the second 40% larger than the participant (Larger-size VB); and finally, a repetition of the first avatar, with the same body size as the participant (Real-size VB-2) (see Figure 1.2). In each of the three exposures, both procedures were conducted in order to produce the full body ownership illusion (FBOI) and to measure the gaze behavior.

- ***Visuo-tactile stimulation procedure***: To enhance the illusion of owning an avatar with different body sizes, a visuo-tactile stimulation procedure was applied, consisting of a series of continuous touches to specific body parts (15 seconds for each arm, 30 seconds for the abdomen, and 15 seconds for each leg) by the researcher with one of the HTC-VIVE controllers, while the participants looked at themselves (first-person perspective). After a minute and a half, a mirror appeared on the wall in front of the avatar and the participants were asked to look at the avatar reflected in the mirror while they repeated the same tactile procedure (third-person perspective).

After the visuo-tactile stimulation procedure, FBOI levels were assessed in each VB condition using a visual analog scale ranging from 0 (none) to 100 (completely).

- ***Eye-tracking assessment task:*** The device used to record the eye movements was the Pupil Labs HTC Vive Eye-Tracking device, a 120 Hz contact-free binocular ET add-on for the VR-Head Mounted Display (HTC VIVE) with a spatial accuracy of one degree and a gaze precision of 0.08 degrees. The accuracy of the ET recordings was measured using a nine-point calibration procedure. After the calibration and validation procedure, participants were instructed to gaze at the avatar reflected in the mirror for 30 s while spontaneous eye movements were recorded (a similar recording time was used in the studies of Jansen et al., 2005; Roefs et al., 2008). Throughout this process participants were advised to avoid abrupt head movements. As a cover story, they were told to remain still while the virtual avatar position was being recalibrated.

2.4. Statistical analyses

Ogama software (Open Gaze Mouse Analyzer) was used to transform the ET raw data into suitable quantitative data. An additional data transformation was conducted by subtracting the difference between weight-related and non-weight-related AOIs (e.g., in Fixation Points (W-AOIs: 25 – NW-AOIs: 10 = 15). Therefore, a positive outcome would mean that the participant had been looking more at the W-related body parts than at the NW-related body parts, while a negative outcome would mean the opposite.

Likewise, women and men were divided into high vs low BD levels using the median score of the EDI-BD as a cut-off point in both genders (M_e-BD = 8 in women, M_e-BD = 3 in men).

Three-way mixed multivariate analyses of variance (MANOVA) were conducted, with two between-subject factors (the gender and BD level conditions), a within-subject factor (the assessment condition) and two combined dependent variables – ET number of fixations, and ET complete fixation time.

All assumptions for the analysis were met. There was a linear relationship between the dependent variables, as assessed by scatterplots. Dependent variables were moderately correlated, as assessed by the Pearson correlation ($|r| < 0.9$). Data for all the variables were distributed normally, as assessed by the Kolmogorov-Smirnov test. There was homogeneity of covariance matrices, as assessed by Box's M test (p = .014), and homogeneity of variances, as assessed by Levene's Test ($p > .05$).

3. Results

3.1. Descriptive results

The following descriptive results for BD levels for women and men are reported. Means (M) and standard deviation (SD) are stated for women with high BD (M = 14.35, SD = .97) and low BD (M = 3, SD = .51), and men with high BD (M = 9, SD = 1.10) and low BD (M = .9, SD =.16) values. In addition, descriptive results of the two ET dependent variables levels are specified for each experimental condition in Table 1.

3.2. Visual selective attention measures

The three-way mixed MANOVA revealed no significant three-way interaction between BD level*gender*time (F (4, 324) = .718, p = .579, Wilks' Λ = .982, partial η^2 = .009) in the combined ET measures. However, there was a statistically significant two-way interaction (F (4, 324) = 4.857, p= .001, Wilks' Λ = .889, partial η^2 = .057) between gender*time in the combined ET variables, with medium effect sizes (Cohen, 1988).

Follow up univariate two-way mixed ANOVAs were run (see table 2). These analyses showed a statistically significant interaction effect (p<.05) between gender*time for both number of fixations and complete fixation time, with medium effect sizes (Cohen, 1988). Therefore, post-hoc pairwise comparisons were conducted. As shown in Table 3, there were statistically significant gender differences in the three assessment conditions (p<.05) for both number of fixations and complete fixation time. According to Cohen (1988), effect sizes were large in all reported comparisons (η^2<.13).

Overall, women showed a higher number of fixations and spent more time looking at the weight-related AOIs than men, while men showed a visual selective behavior toward the non-weight-related AOIs (Figures 2.1 and 2.2). These significant gender differences were especially noticeable in the third condition, when participants owned their real-size VB for the second time, for both AB gaze variables.

Since men showed a higher number of fixations and a longer complete fixation time toward non-weight-related AOIs, a multivariate post-hoc analysis was conducted in order to assess whether an AB toward muscular-related body parts might explain this gaze behavior. In accordance with the body items loading for muscularity of the Body Esteem Scale (BES, Franzoi & Shields, 1984) and the Male Body Checking Questionnaire (MBCQ, Hildebrandt, Walker, Alfano, Delinsky, & Bannon, 2010), muscular-related body parts (M-AOIs) were labeled as: chest, arms, shoulders, abdomen, and lower-legs. The remaining body areas were labeled as non-muscular-related body parts (NM-AOIs).

Multivariate analyses reported no significant three-way interactions between BD group*gender*time (F (4, 324) = 0.986, p = .413, Pillai's Trace = .976.982, partial η^2 = .012) on the combined ET measures. However, there were statistically significant two-way interactions (F (4, 324) = 6.846, p = <.001, Pillai's Trace = 0.856, partial η^2 = .075) between gender*time on the combined ET variables, with medium effect sizes (Cohen, 1988).

Follow up univariate two-way mixed ANOVAs were run. These analyses showed a statistically significant interaction effect (p<.05) between gender*time for number of fixations and a marginally significant interaction effect (p =.059) for complete fixation time (see table 2), with medium and small effect sizes (Cohen, 1988). Accordingly, there were significant gender differences in the gaze behavioral patterns toward muscular- and non-muscular-related body areas across the three conditions (table 3), and with a large effect size (η^2<.13), according to Cohen (1998). Overall, men showed a higher number of fixations and spent more time looking at the muscular-related AOIs, specifically when they owned their real-size VB for the first and second times (figures 3.1 and 3.2). Women, in turn, showed a clear AB to non-muscular-related AOIs across the three conditions.

4. Discussion

The current study confirmed the assumption that women and men evaluate their appearance in different ways (Alfano et al., 2011), using an objective AB measure. As expected, regardless of self-reported BD, women and men showed completely different gaze behavior patterns toward their own body. Consistent with a previous pilot study (Porras-Garcia et al., 2018), women showed a tendency to pay more attention than men to weight-related body areas in all body size conditions, whereas men paid more attention to non-weight-related body areas.

In addition, an interesting visual tendency that was observed in the same pilot study, i.e. that gender differences were higher when participants owned the real-size VB for the second time compared with the previous VB size conditions (Porras-Garcia et al., 2018), was confirmed in this study with a larger sample size and with a similar number of women and men.

Several ET studies have found that adult women with ED showed AB toward self-reported unattractive body areas, while healthy participants showed more general scanning behavior over the entire body (Freeman et al., 1991; Jansen et al., 2005; Tuschen-Caffier et al., 2015). Initially, our results did not seem to support these studies, as overall women showed a tendency to focus on the weight-related body parts, being these often self-reported as unattractive body areas or body areas of higher concern (Janelle, Hausenblas, Ellis, Coombes, & Duley, 2009; Stanford & McCabe, 2002). However, when we consider BD levels, and even though differences between high vs low body-dissatisfied women and men did not reach statistical significance, we found that women with high BD spent more time looking at weight-related body parts than women with low BD, who in turn showed a general scanning behavior over the body comparable to the visual behavior observed in other studies of healthy participants (Freeman et al., 1991; Jansen et al., 2005; Tuschen-Caffier et al., 2015).

When we considered BD levels among men, we found interesting tendencies. Whereas men with high BD spent more time and had a higher number of fixations looking at the non-weight-related body areas, regardless of body size condition, men with low BD showed a more fluctuant gaze behavior depending on the body size of the virtual avatar that they owned. Thus, when they owned the larger-size VB, men with low BD showed a more general scanning behavior over the whole body, compared to those with high BD. These results may be attributed to an avoidance gaze behavior toward the weight-related body areas. A previous study found that being exposed to a larger-size VB elicited high body anxiety levels in healthy women and men (Ferrer-Garcia et al., 2017). Accordingly, this avoidance gaze behavior may be influenced by the high anxiety response to owning a larger VB. Consistent with this hypothesis, previous studies on women found that higher levels of dissatisfaction with specific body regions predicted less visual attention to those regions (Lykins, Ferris, & Graham, 2014). Therefore, men with high BD may follow a similar avoidance-type process when they own a larger-size VB.

Furthermore, the multivariate post-hoc analyses between muscular- and non-muscular-related AOIs provide preliminary evidence for an AB related to muscularity in men. This AB toward muscular-related body parts was especially noticeable when participants owned their real-size VB for the first and second times. Our results support those of previous studies that have found an AB toward muscular bodies (Cho & Lee, 2013; Jin, et al., 2018), or toward muscular-related body parts (Nikkelen, Anschutz, Ha, & Engels, 2012) among men.

Interestingly, in the larger-size VB condition, men presented a slight change in their gaze behavior, spending more time looking at non-muscular-related body parts than in the first and second real-size VB conditions. A possible explanation for these results is that slimness, as well as muscularity, is a significant body-related concern among men (Alfano et al., 2011). Therefore, owning a larger-size VB may elicit body image concerns related more to weight gain than to muscularity, resulting in an avoidance gaze behavior so as not to attend to areas associated with weight (as can be seen in the previous analyses), or muscularity – for instance the face, the neck or the hands.

Relatedly, the dichotomy between slimness and muscularity in men’s body image concerns may also explain the differences when comparing weight/non-weight and muscular/non-muscular-related AOI analyses, in which women showed a more evident and noticeable AB toward weight-related AOIs, and men an AB toward muscular-related AOIs.

The greatest gender differences were found when participants owned the real-size VB for the second time. These differences were found in both weight/non-weight and muscular/non-muscular-related AOIs analyses. Curiously, these differences were based on an increase in the number and duration of fixations on weight-related body parts only in women, compared to the previous body size conditions. In contrast, men showed a similar gaze behavior pattern toward non-weight/muscular-related AOIs, as in the first real-size VB condition. One possible explanation for this is that, after owning the larger-size VB, when participants owned their real-size VB for the second time, they did not see it as their real body, but as a thinner body. This misperception of the body may be elucidated by a visual adaptation effect (Challinor et al., 2017), which arises as a long-term exposure to an extreme stimulus leads to seeing subsequent stimuli in a distorted fashion (Challinor et al., 2017). In body image research, exposure to thin (fat) body images resulted in perceiving the previously self-reported normal-sized body images as fatter (thinner) than before (Robinson & Kirkham, 2014; Stephen, Sturman, Stevenson, Mond, & Brooks, 2018; Winkler & Rhodes, 2005). Anecdotally, after exposure to a larger VB, several women reported that when they owned their real-size VB for the second time, it appeared thinner than it was the first time. Accordingly, gender differences in self-reported FBOI levels were only observed in the third real-size VB condition, in which men showed the same high FBOI levels as in the first real-size VB condition, while women showed a significant fall in FBOI levels compared with the first real-size VB condition. Therefore, we suggest that the visual adaptation effect may affect body-related attention to specific body parts differently in women and men, with an increase in body checking behaviors toward the body areas of higher concern (weight-related body parts) only in women, when they owned the self-perceived thinner-idealized VB (real-size VB-2) for the second time. This misperception effect may not have equally affected body-related attention in men.

Interestingly, women with high BD spent more time looking at the weight-related body parts compared with women with low BD. These results are consistent with previous studies that reported that women and men with a high drive for thinness showed AB toward weight-related body parts when they were exposed to pictures of young, attractive men and women (Hewig et al., 2008). Likewise, BD seems to be strongly associated with an attentional preference toward idealized bodies over other types of bodies in both genders (Cho & Lee, 2013; Joseph et al., 2016).

Some important limitations should be considered. First, neither BMI (Roefs et al., 2008), nor drive for thinness levels (Cordes et. al., 2016; Hewig et al., 2008; Janelle, Hausenblas, Fallon, & Gardner, 2003) were controlled in this study, although they have been considered as important factors in body-related attention. Second, some of the body parts labeled as non-weight-related AOIs (e.g., the arms or the chest) may also be affected by an increase in weight, and thus considered as unattractive body parts. However, we preferred to draw the weight-related AOIs based on a weight scale of an evidence-based body anxiety questionnaire (PASTAS, Reed et al., 1991). Third, the BD levels reported by our high body dissatisfied women and men corresponded to the 57th percentile of the BD scale reported in a non-clinical sample of Spanish adults (Elosua, López-Jáuregui, & Sánchez-Sánchez, 2010). Thus, the BD levels reported by our high BD participants represent the typical medium to high BD levels among non-clinical samples in the Spanish population. Therefore, it would have been necessary to recruit participants with higher levels of BD in order to provide a more exhaustive distinction of the BD levels among women and men.

The present study initially focused on AB toward weight-related AOIs, since a modification of the silhouette of the avatar was conducted, specifically by increasing the shape of the weight-related body parts (larger-size VB). The findings regarding an AB for muscular-related AOI in men should be explored further in future research by using an experimental design which applies a modification of the shape of muscular-related body parts, resulting in a realistic representation of a muscular or hyper-muscular VB. In addition, future research should focus not only on assessing body-related AB, but on modifying dysfunctional body-related AB as well. For instance, some previous studies have already induced a temporary AB toward (un)attractive body areas in order to elicit higher body satisfaction levels in women with high BD (Glashouwer, Jonker, Thomassen, & de Jong, 2016; Jansen et al., 2016; Smeets et al., 2011). Therefore, future studies could follow a similar approach by taking advantage of VR-based embodiment techniques, with the aim of re-training dysfunctional body-related attention in individuals with high BD or in ED patients while they own a virtual avatar with their real body measurements or with a different body size.

This novel gender-based study provides new evidence on gender differences in visual selective attention toward specific body parts, in which women showed a clear AB toward weight-related body parts in comparison with men. Interesting preliminary findings are also provided about a specific AB toward muscular-related body parts among men.

Even though there were no statistically significant differences between high vs low body-dissatisfied women and men in any of the body size conditions, our results suggest that BD may play an important role in eye-gaze behaviors toward weight-related body parts.

As stated in previous studies, BD is considered a core feature of ED pathology among women (e.g., Stice et al., 2017) and men (e.g., Blashill, 2011; Dakanalis et al., 2015). Achieving a better understanding of the mechanisms underlying and maintaining BD, such as a dysfunctional body-related attention (Rodgers & DuBois, 2016), is essential to the design of future psychological ED assessment and treatments. Clinical interventions aiming to modify BD may be able to draw on our findings in order to design specific gender-based interventions that aim to retrain dysfunctional body-related attention in different ways in women and men with ED.

In addition, by combining VR with ET devices, future ED assessments and treatments could take advantage of the innumerable possibilities of VR (e.g., owning a VB with the same measurements) while real-time visual attention is objectively measured.

Acknowledgments. This study was supported by the Spanish Ministry Economy and Competitiveness (MINECO/FEDER/UE/ Project PSI2015-70389-R: Development of virtual reality-based exposure techniques for improving anorexia nervosa treatment); and by the AGAUR, Generalitat de Catalunya, 2017SGR1693.

References

Alfano, L., Hildebrandt, T., Bannon, K., Walker, C., & Walton, K. E. (2011). The impact of gender on the assessment of body checking behavior. *Body Image*. *8*, 20-25. https://doi.org/10.1016/j.bodyim.2010.09.005

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5*. Washington, D.C: American Psychiatric Association. http://dx.doi.org/10.1176/appi.books.9780890425596

Blashill, A. J. (2011). Gender roles, eating pathology, and body dissatisfaction in men: A meta-analysis. *Body image, 8*(1), 1-11. https://doi.org/10.1016/j.bodyim.2010.09.002

Cash, T. F., & Brown, T. A. (1987). Body image in anorexia nervosa and bulimia nervosa. A review of the literature. *Behavior Modification, 11*(4), 487-521. https://doi.org/10.1177/01454455870114005

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

Challinor, K. L., Mond, J., Stephen, I. D., Mitchison, D., Stevenson, R. J., Hay, P., & Brooks, K. R. (2017). Body size and shape misperception and visual adaptation: An overview of an emerging research paradigm. *Journal of International Medical Research*, *45*(6), 2001–2008. https://doi.org/10.1177/0300060517726440

Cho, A., & Lee, J. H. (2013). Body dissatisfaction levels and gender differences in attentional biases toward idealized bodies. *Body Image, 10*(1), 95-102 . https://doi.org/10.1016/j.bodyim.2012.09.005

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Second Edition. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Cordes, M., Vocks, S., Düsing, R., Bauer, A., & Waldorf, M. (2016). Male body image and visual attention towards oneself and other men. *Psychology of Men and Masculinity*, *17*(3), 243. https://doi.org/10.1037/men0000029

Dakanalis, A., Zanetti, A. M., Riva, G., Colmegna, F., Volpato, C., Madeddu, F., & Clerici, M. (2015). Male body dissatisfaction and eating disorder symptomatology: Moderating variables among men. *Journal of Health Psychology, 20*(1), 80-90. https://doi.org/10.1177/1359105313499198

Elosua, P., López-Jáuregui, A., & Sánchez-Sánchez, F. (2010). *Adaptación española del Eating Disorder Inventory-3. Normalización y validación.* [Spanish adaptation of the Eating Disorder Inventory-3. Standardization and validation]. Madrid: TEA.

Fiske, L., Fallon, E. A., Blissmer, B., & Redding, C. A. (2014). Prevalence of body dissatisfaction among United States adults: Review and recommendations for future research. *Eating Behaviors*, *15*(3), 357-365. https://doi.org/10.1016/j.eatbeh.2014.04.010

Ferrer-Garcia, M., Porras-Garcia, B., González-Ibañez, C., Gracia-Blanes, M., Vilalta-Abella, F., Pla-Sanjuanelo, J., … Gutiérrez-Maldonado, J. (2017). Does owning a “fatter” virtual body increase body anxiety in college students? *Annual Review of CyberTherapy and Telemedicine*, *15*, 147–153.

Freeman, R., Touyz, S., Sara, G., Rennie, C., Gordon, E., & Beumont, P. (1991). In the eye of the beholder: Processing body shape information in anorexic and bulimic patients. *International Journal of Eating Disorders*, *10*(6), 709-714. https://doi.org/10.1002/1098-108X(199111)10:6<709::AID-EAT2260100609>3.0.CO;2-N

Franzoi, S. L., & Shields, S. A. (1984). The Body Esteem Scale: Multidimensional structure and sex differences in a college population. *Journal of personality assessment*, *48*(2), 173-178. https://doi.org/10.1207/s15327752jpa4802_12

Garner, D. (2004). EDI-3 (Eating Disorder Inventory-3). Professional Manual. Lutz, FL: *Psychological Assessment Resources*, Incorporated. https://doi.org/10.1371/journal.pone.0136173

Glashouwer, K. A., Jonker, N. C., Thomassen, K., & de Jong, P. J. (2016). Take a look at the bright side: Effects of positive body exposure on selective visual attention in women with high body dissatisfaction. *Behaviour research and therapy*, *83*, 19-25. https://doi.org/10.1016/j.brat.2016.05.006

Grogan, S. (2016). Body image: *Understanding body dissatisfaction in men, women and children*. London: Routledge.

Gutiérrez-Maldonado, J., Ferrer-Garcia, M., Dakanalis, A., & Riva, G. (2018). Virtual reality: Applications to eating disorders. In W.S. Agras, A.H. Robinson (Eds.) *The Oxford handbook of eating disorders*. Oxford. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190620998.013.26

Haase, A. M., Mountford, V., & Waller, G. (2011). Associations between body checking and disordered eating behaviors in nonclinical women. *International Journal of Eating Disorders*, *44*(5), 465-468. https://doi.org/10.1002/eat.20837

Hans-Martin Lutz, O., Burmeister, C., Santos, L. F. dos, Morkisch, N., Dohle, C., & Krüger, J. (2017). Application of head-mounted devices with eye-tracking in virtual reality therapy. *Current Directions in Biomedical Engineering*, *3*, 53–56. https://doi.org/10.1515/cdbme-2017-0012

Hewig, J., Cooper, S., Trippe, R. H., Hecht, H., Straube, T., & Miltner, W. H. R. (2008). Drive for thinness and attention toward specific body parts in a nonclinical sample. *Psychosomatic Medicine*, *70*(6), 729-736. https://doi.org/10.1097/PSY.0b013e31817e41d3

Hildebrandt, T., Walker, D. C., Alfano, L., Delinsky, S., & Bannon, K. (2010). Development and validation of a male specific body checking questionnaire. *International Journal of Eating Disorders*, *43*(1), 77-87. https://doi.org/10.1002/eat.20669

Jacob, R. J. K., & Karn, K. S. (2003). Eye Tracking in Human-Computer Interaction and Usability Research. Ready to Deliver the Promises. In *The Mind's Eye:*

Cognitive and Applied Aspects of Eye Movement Research. https://doi.org/10.1016/B978-044451020-4/50031-1

Janelle, C. M., Hausenblas, H. A., Fallon, E. A., & Gardner, R. E. (2003). A visual search examination of attentional biases among individuals with high and low drive for thinness. *Eating and Weight Disorders*, *8*(2), 138-144. https://doi.org/10.1007/BF03325003

Janelle, C. M., Hausenblas, H. A., Ellis, R., Coombes, S. A., & Duley, A. R. (2009). The time course of attentional allocation while women high and low in body dissatisfaction view self and model physiques. *Psychology and Health*, *24*(3), 351-366. https://doi.org/10.1080/08870440701697367

Jansen, A., Nederkoorn, C., & Mulkens, S. (2005). Selective visual attention for ugly and beautiful body parts in eating disorders. *Behaviour Research and Therapy*, *43*(2), 183-196. https://doi.org/10.1016/j.brat.2004.01.003

Jansen, A., Voorwinde, V., Hoebink, Y., Rekkers, M., Martijn, C., & Mulkens, S. (2016). Mirror exposure to increase body satisfaction: Should we guide the focus of attention towards positively or negatively evaluated body parts? *Journal of Behavior Therapy and Experimental Psychiatry*, *50*, 90–96. https://doi.org/10.1016/j.jbtep.2015.06.002

Jiang, M. Y. W., & Vartanian, L. R. (2018). A review of existing measures of attentional biases in body image and eating disorders research. *Australian Journal of Psychology*, *70*(1), 3-17 https://doi.org/10.1111/ajpy.12161

Jin, X., Jin, Y., Zhou, S., Yang, S. N., Chang, S., & Li, H. (2018). Attentional biases toward body images in males at high risk of muscle dysmorphia. *PeerJ*, *6*, e4273. https://doi.org/10.7717/peerj.4273

Joseph, C., LoBue, V., Rivera, L. M., Irving, J., Savoy, S., & Shiffrar, M. (2016). An attentional bias for thin bodies and its relation to body dissatisfaction. *Body Image*, *19*, 216–223. https://doi.org/10.1016/j.bodyim.2016.10.006

Kerr- Gaffney, J., Harrison, A., & Tchanturia, K. (2019). Eye- tracking research in eating disorders: A systematic review. *International Journal of Eating Disorders*, *52*(1), 3-27. https://doi.org/10.1002/eat.22998

Kredel, R., Vater, C., Klostermann, A., & Hossner, E.-J. (2017). Eye-Tracking Technology and the Dynamics of Natural Gaze Behavior in Sports: A Systematic Review of 40 Years of Research. *Frontiers in Psychology*, *8*, 1845. http://doi.org/10.3389/fpsyg.2017.01845

Lee, M., & Shafran, R. (2004). Information processing biases in eating disorders. *Clinical Psychology Review*, *24*(2), 215-238. https://doi.org/10.1016/j.cpr.2003.10.004

Legenbauer, T., Thiemann, P., & Vocks, S. (2014). Body image disturbance in children and adolescents with eating disorders: Current evidence and future directions. *Zeitschrift Fur Kinder- Und Jugendpsychiatrie Und Psychotherapie*, *42*, 51-59. https://doi.org/10.1024/1422-4917/a000269

Lykins, A. D., Ferris, T., & Graham, C. A. (2014). Body region dissatisfaction predicts attention to body regions on other women, *Body Image*, *11*(4), 404-408. https://doi.org/10.1016/j.bodyim.2014.05.003

Maselli, A., & Slater, M. (2013). The building blocks of the full body ownership illusion. *Frontiers in Human Neuroscience*, *7*, 83. https://doi.org/10.3389/fnhum.2013.00083

Nikkelen, S. W., Anschutz, D. J., Ha, T., & Engels, R. C. (2012). Influence of visual attention on male body dissatisfaction after idealized media exposure. *Psychology of Men & Masculinity*, *13*(3), 308. http://dx.doi.org/10.1037/a0024942

Porras-Garcia, B., Ghita, A., Moreno, M., Ferrer-Garcia, M., Pla-Sanjuanelo, J., Bertomeu-Panisello, P., … & Gutiérrez-Maldonado, J. (2018). Gender differences in attentional bias after owning a virtual avatar with increased weight. *Annual Review of Cybertherapy and Telemedicine*, *16*, 73-79.

Reed, D. L., Thompson, J. K., Brannick, M. T. & Sacco, W. P. (1991). Development and validation of the Physical Appearance State and Trait Anxiety Scale (PASTAS), *Journal of Anxiety Disorders*, *5*, 323–332. http://dx.doi.org/10.1016/08876185(91)90032-O

Rodgers, R. F., & DuBois, R. H. (2016). Cognitive biases to appearance-related stimuli in body dissatisfaction: A systematic review. *Clinical Psychology Review*, *46*, 1-11. https://doi.org/10.1016/j.cpr.2016.04.006

Robinson, E., & Kirkham, T. C. (2014). Is he a healthy weight? Exposure to obesity changes perception of the weight status of others. *International Journal of Obesity*, *38*(5), 663–667. https://doi.org/10.1038/ijo.2013.154

Roefs, A., Jansen, A., Moresi, S., Willems, P., van Grootel, S., & van der Borgh, A. (2008). Looking good. BMI, attractiveness bias and visual attention. *Appetite*, *51*(3), 552-555. https://doi.org/10.1016/j.appet.2008.04.008

Smeets, E., Jansen, A., & Roefs, A. (2011). Bias for the (un)Attractive Self: On the Role of Attention in Causing Body (dis)Satisfaction. *Health Psychology*, *30*, 360–367. https://doi:10.1037/a0022095

Stanford, J. N., & McCabe, M. P. (2002). Body image ideal among males and females: Sociocultural influences and focus on different body parts. *Journal of Health Psychology*, *7*(6), 675-684. https://doi.org/10.1177/1359105302007006871

Stephen, I. D., Sturman, D., Stevenson, R. J., Mond, J., & Brooks, K. R. (2018). Visual attention mediates the relationship between body satisfaction and susceptibility to the body size adaptation effect. *PLoS ONE*, *13*(1). https://doi.org/10.1371/journal.pone.0189855

Stice, E., Ng, J., & Shaw, H. (2010). Risk factors and prodromal eating pathology. *Journal of Child Psychology and Psychiatry*, *51*(4), 518-525. https://doi.org/10.1111/j.1469-7610.2010.02212.x

Stice, E., Gau, J. M., Rohde, P., & Shaw, H. (2017). Risk factors that predict future onset of each DSM–5 eating disorder: Predictive specificity in high-risk adolescent females. Journal of Abnormal Psychology, 126, 38–51. http://dx.doi.org/10.1037/abn0000219

Tuschen-Caffier, B., Bender, C., Caffier, D., Klenner, K., Braks, K., & Svaldi, J. (2015). Selective visual attention during mirror exposure in anorexia and bulimia nervosa. *PLoS ONE, 10*(12), e0145886. https://doi.org/10.1371/journal.pone.0145886

Walker, D. C., Anderson, D. A., & Hildebrandt, T. (2009). Body checking behaviors in men. *Body image, 6*(3), 164-170. https://doi.org/10.1016/j.bodyim.2009.05.001

Winkler, C., & Rhodes, G. (2005). Perceptual adaptation affects attractiveness of female bodies. *British Journal of Psychology, 96*, 141-154. https://doi.org/10.1348/000712605X36343

Williamson, D. A., White, M. A., York-Crowe, E., & Stewart, T. M. (2004). Cognitive-behavioral theories of eating disorders. *Behavior Modification, 28*, 711-738. https://doi.org/10.1177/0145445503259853

World Health Organization (2004). *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Volume 2. International Classification of Diseases and Related Health Problems. Tenth Revision. Volume 2*. https://doi.org/10.1007/978-1-4899-0762-2_20

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Tables

Table 1. Descriptive outcome means (M) and standard deviation (SD) of the Eye-tracking measures stated in body dissatisfaction (BD) levels among women and men, at the different assessment time conditions.

		Weight and non-weight-related AOIs		**Muscular and non-muscular-related AOIs**	
		Complete fixation time M (SD)	Number of fixations M (SD)	Complete fixation time M (SD)	Number of fixations M (SD)
Real-size VB	High BD women	3188.96 (8299.13)	9.35 (19.156)	-3767.35 (5120.22)	-9.78 (11.50)
	Low BD women	510.18 (6200.84)	7.55 (13.917)	-1470.41 (6104.14)	-6.68 (12.71)
	High BD men	-10132.30 (10503,54)	-15.05 (13.85)	1761.45 (10018.28)	.80 (9,46)
	Low BD men	-8842.50 (6568.67)	-15.90 (13.94)	71.20 (6058.58)	1.30 (11,77)
Larger-size VB	High BD women	2289.74 (7227.64)	9.26 (16.67)	-3447.96 (4112.89)	-8.35 (10.74)
	Low BD women	564.64 (8118.01)	8.05 (14.61)	-4319,32 (3835.59)	-10.27 (10.92)
	High BD men	-7305.70 (5855.99)	-15.90 (12.63)	-1350,55 (5511.51)	2.30 (10.76)
	Low BD men	-2349.50 (6442,50)	-4.35 (13.59)	-32.50 (5582.20)	2.60 (10.00)
Real-size VB-2	High BD women	8428.87 (10422.67)	21.17 (26.81)	-7858.78 (7096.81)	-21.30 (17.89)
	Low BD women	2435.41 (6454.34)	14.55 (15.04)	-5009.27 (8321.36)	-18.95 (18.57)
	High BD men	-8148.05 (11841.16)	-15.80 (15.91)	-389.60 (6326.66)	2.30 (10.76)
	Low BD men	-10098.55 (10329.64)	- 23.00 (22.38)	1165.40 (6823.43)	6.80 (14.81)

Note: Women with high (n=23) vs low (n=22) body dissatisfaction levels, men with high (n=20) vs low (n=20) body dissatisfaction levels. Different assessment time (1st – real-size virtual body, 2nd – larger-size virtual body and 3rd – real-size virtual body second time). VB= Virtual body. AOIs= Areas of Interest group.

Table 2. Two-way mixed univariate analyses of variance (ANOVA) comparing gender and the different assessment time.

	Weight vs non-weight-related AOIS (gender*time)			Muscular vs non-muscular-related AOIs (gender*time)		
	F	*p*	η^2	*F*	*p*	η^2
Complete fixation time	6.019	.003*	.069	2.884	.059	.034
Number of fixations	6.019	<.001*	.090	12.46	<.001*	.133

Note: Gender and the different assessment times (1st – real-size virtual body, 2nd – larger-size virtual body and 3rd – real-size virtual body second time). AOIs= Areas of Interest group. * Significant *p* values < 0.05.

Table 3. Post-hoc analyses (pairwise comparison) of gender differences at the different assessment times.

	Weight vs non-weight related AOIS								
	1st real-size VB			2nd larger-size VB			3rd real-size VB-2		
	Women vs Men			Women vs Men			Women vs Men		
	F	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2
Complete fixation time	42.074	<.001*	.342	16.885	<.001*	.172	45.665	<.001*	.361
Number of fixations	50.383	<.001*	.383	35.281	<.001*	.303	68.240	<.001*	.457
	Muscular vs non-muscular-related AOIs								
	1st real-size VB			2nd larger-size VB			3rd real-size VB-2		
	Women vs Men			Women vs Men			Women vs Men		
	F	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2
Complete fixation time	5.407	.023	.063	9.444	.003	.104	18.969	<.001*	.190
Number of fixations	13.892	<.001*	.190	25.131	<.001*	.237	50.563	<.001*	.384

Note: VB = Virtual Body. * Significant *p* values < 0.05.

Figure captions

Figure 1.1. Visual description of the weight-related and non-weight-related Areas of Interest (AOIs), in the female and male virtual avatars.

Figure 1.2 Experimental design. Two between-subjects gender and BD levels conditions (high vs low body dissatisfaction), a within-subject assessment time condition (real-size virtual body (VB), larger-size VB and real-size VB-2) and reported dependent variables (eye-tracking measures).

Figure 2.1 and 2.2. Gender differences in mean complete fixation time, in milliseconds (ms), and number of fixations at weight vs non-weight-related Areas of Interest (AOIs), for each assessment time condition. Error bars represent standard error (SE), based on 2SE.

Figure 3.1 and 3.2. Gender differences in mean complete fixation time, in milliseconds (ms), and number of fixations at muscular vs non-muscular-related Areas of Interest (AOIs), for each assessment time condition. Error bars represent standard error (SE), based on 2SE.