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Gender differences in attentional bias after owning a virtual avatar with increased weight.

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Introduction: Eating Disorder (ED) patients selectively attend to appearance cues in preference to other information, in a phenomenon known as Attentional Bias (AB). The latest VR Head Mounted Displays (HMD) offer the chance to include Eye-Tracking (ET) devices, and thus provide more objective measures of body-related attention. This study aims to combine VR and ET technologies and use a VR-based embodiment technique while measuring real-time attention patterns. Specifically, we assess gender differences in eye-gaze behaviors towards specific weight-related or non-weight-related body parts when participants own a virtual avatar with different body sizes. **Method:** Thirty-five college students (25 women and 10 men) were exposed to an immersive virtual environment in which they were embodied in three avatars with different body sizes: first, one with the same body size as the participant; second, one larger than

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the participant; and finally, repetition of the avatar with the same body size as the participant. To analyze the gaze data Weight-related Areas of Interest (W-AOIs) and Non-Weight-related Areas of Interest (NW-AOIs) were defined. Fixation points and complete fixation time on each AOI were recorded at the three different assessment times. Raw data from the Pupil Labs eye tracking add-on for the HTC-Vive headset were subsequently transformed into percentages for further analysis. **Results:** Mixed between (Gender)-within (Time) analyses of variance showednon-statistically significant interaction between gender and time (*p*>.05) and a non-statistically significant difference in fixation points and complete fixation times (*p*>.05), over the three assessment times. However, a statistically significant gender difference was found in fixation points (F (1.33) =10,030, p= .003, η2 = 0.233) and complete fixation time (F (1.33) =13,017, p= .001, η2 = 0.28. Overall, women reported significantly higher levels of fixation points and complete fixation times in W-AOIs than men. Women showed an increasing gaze pattern towards W-AOIs at the three different assessment times, while men showed an opposite gaze pattern towards NW-AOIs at the three different times. Interestingly, the greatest differences between men and women were found at the third assessment, when they once again owned an avatar with the same body size as themselves. Conclusion: This study provides useful information about gender differences in gaze pattern behaviors while participants owned a virtual avatar with different body sizes. To our knowledge, this is the first study to compare gaze pattern behaviors between women and men using VR-based embodiment techniques and ET attentional bias assessment. The use of these two technologies opens a promising new area in the assessment or treatment of Eating Disorders and body image disturbances.

Keywords: Eye-tracking, virtual reality, gender differences, eye-gaze pattern behaviors.

1. Introduction

Cognitive models of Eating Disorder (ED) have suggested the presence of a dysfunctional body-related attention. According to these models, ED patients show a preference for attending to disorder-relevant information, such as body-related stimuli, over other sorts of information, in a phenomenon known as Attentional Bias (AB) [1]. According to DSM 5, all ED patients tend to over-evaluate their shape and weight [2]: some of them by repeatedly checking and scrutinizing their weight-related body parts, for example by looking at themselves in the mirror (body checking), and others by actively avoiding any such inspection (body avoidance). The use of eye-tracking (ET) techniques has provided a direct and continuous measure of AB [3] which may represent a useful way to assess both attentional strategies. In clinical studies, some authors suggest that female ED patients tend to attend more 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 [4]. However, a recent ET study showed that female adolescents with different types of ED and healthy participants pay more attention to self-attributed unattractive body parts [5].

To date, most studies have assessed visual attention bias only in females, while little research has focused on the study of gender differences in body-related attention. The suggestion is that women and men differ in their body image concerns and present different ways of evaluating their appearance: while women tend to check body areas related with weight (e.g., the thighs), men tend to check body areas related with muscularity (e.g., the arms) [6]. Two previous studies have assessed AB for different body shapes in women and men, and its relationship with body dissatisfaction. The results show that both genders attend more to idealized bodies (i.e., muscular male bodies or thin female bodies) over other types of bodies, and that body dissatisfaction seems to be strongly related with an AB toward idealized bodies in both genders [7,8].

However, eye-movement research also presents some important limitations, such as the lack of external validity. The use of VR technology may help to overcome these drawbacks by adding eye-tracking devices into the Head-mounted display (HMD). The combination of the two technologies can capitalize on the possibilities of VR scenarios by measuring real-time attention patterns objectively and accurately [9]. In addition, the use of embodiment VR-based techniques provides participants with the chance to see their own virtual bodies in a first-person perspective or by looking at themselves in a mirror [10] and creating real-size 3D virtual avatars to assess and change their mental representations of their body image [11].

This study aims to assess gender differences in eye-gaze behaviors towards specific weight-related or non-weight-related body parts in a situation in which participants own a virtual avatar with different body sizes. It is expected that female participants will spend a greater proportion of time and frequency of fixations looking at weight-related body parts, while males will show an opposite gaze behavior pattern, looking more at the non-weight-related body parts.

2 Method

2.1 Participants

Thirty-five college students from the University of Barcelona, 25 women and 10 men (M_{age} = 22.30, *SD* = 2.76, M_{BMI} = 21.78, *SD* = 2.47) participated in the study. They were recruited through campus flyers and advertisements in social network groups. The exclusion criteria were diagnosis of a current ED, a BMI less than 17 (moderate thinness) or more than 30 (obesity) and a current Severe Mental Disorder Diagnosis.

2.2 Instruments

The HMD HTC-VIVE with a Pupil Labs Eye-Tracking device add on was used in this experiment, connected to a computer with sufficient graphic and processor power to move VR environments. Two programs were used to develop the virtual simulations: Blender 2.78 v. to create the virtual avatars (male and female) and Unity 3D 5.5.v to integrate all the elements within a virtual environment. The virtual environment was a simple room without any furniture, and with a large mirror on the front wall. This mirror, placed 1.5 meters in front of the subject, was not visible at the beginning of the experiment (first-person perspective) and was activated only during the third-person perspective condition. Two different avatars were created, one male and one female. Both male and female avatars wore a standard black t-shirt with black jeans and black trainers. Both avatars wore a swimming cap so as to reduce the idiosyncratic influence of hairstyle on each participant.

Visual selective attention measures. In accordance with the Weight Scale body items of the Physical Appearance State and Trait Anxiety Scale questionnaire [12], the same areas of interest (AOIs) were individually drawn in a 2D frontal view picture of the female or male avatar and were labelled as weight related body-parts (W-AOIs): e.g., thighs, buttocks, hips, stomach (abdomen), legs, waist. Muscle tone was not included, due to the impossibility of reproducing it. The remaining body areas were labelled as non-weight related body parts (NW-AOIs): e.g., head, shoulders, arms, décolletage, neck and chest. The participant's visual fixation, defined as the visual act of sustaining the gaze on a single location over a minimum duration (typically 100–200 ms) [13], was estimated by the following variables:

- *Proportion of fixations in AOIs:* Proportion of available fixations on the specified area of interest group (weight-related body-parts or non-weight body parts) divided by the total number of fixations available across all areas of interest.
- *Complete fixation time in AOIs*: Proportion of the fixation time on the specified area of interest group (weight-related body-parts or non-weight body parts) divided by the complete fixation time available across all areas of interest.

2.3 Procedure

This study was approved by the ethical committee of the University of Barcelona. Before entering the study, participants signed an informed consent form and were then weighed and measured to calculate their BMI. Afterwards, a photo of the whole body of each participant was taken by the experimenters, using a camera. The photo was adapted to the different virtual avatar measures (e.g. arms, legs, hip, waist, chest, breast, shoulders…).

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 some specific body parts (the arms, the abdomen, and the legs) by the experimenter with one of the HTC-VIVE controllers, while the participants looked at themselves (first-person perspective) and at the avatar reflected in a mirror in front of them (third-person perspective).

Eye-tracking assessment task: The device used to record the eye movements was Pupil Labs HTC Vive Eye-Tracking, a 120 Hz contact free binocular eye-tracking add-on for the VR HMD (HTC VIVE) with a spatial accuracy of one degree. The accuracy of the eye-tracking recordings was measured by a nine-point calibration procedure. After the calibration and validation procedure, participants were instructed to gaze at the avatar reflected in the mirror for 30s while spontaneous eye movements were recorded. Throughout this process they were advised to avoid abrupt head-movements.

Following the two procedures, each participant was exposed to three virtual bodies (assessment time condition): the first with the same body size as the participant (Real-size VB-1); 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).

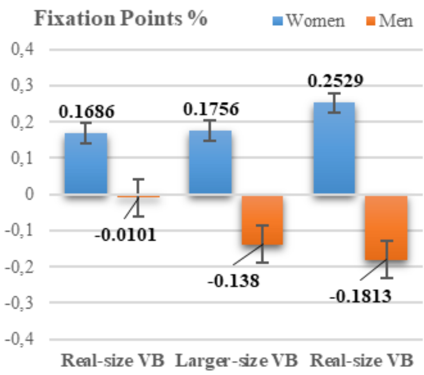
2.4 Statistical analysis

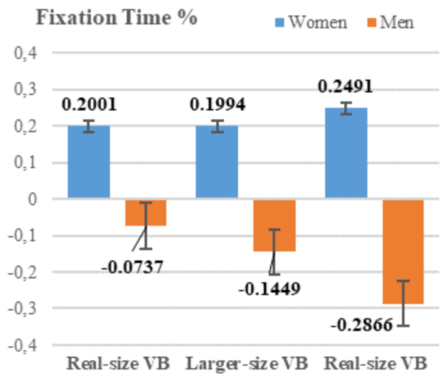
The analysis software Ogama (Open Gaze Mouse Analyzer) was used to transform the eye-tracking raw data into suitable quantitative data. An additional data transformation was conducted by subtracting the difference between weight-related and non-weight-related AOIs (e.g., in Fixation Points (W AOIs: 10 - NW AOIs: 8 = 2) 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. Finally, the previous data were subsequently transformed into percentages for further analysis. The outcome of the intervention, including the AOIs data, was analyzed by the statistical software IBM SPSS Statistics v.23.

3. Results

Mixed between (gender)-within (assessment time) analyses of variance (ANOVA) were conducted. All the assumptions were met; there was homogeneity of variances, sphericity, and normal distribution of the data in both variables. There were no statistically significant interactions between gender and assessment time ($p > .05$) in ET Fixation points or in ET Fixation Time. There was neither a main effect of the assessment time condition in any of the ET variables ($p > .05$). On the other hand, there was a significant main effect of gender in ET Fixation points F (1.33) = 10.030, $p = .003$ $\eta^2 = .233$ and in ET Fixation Time F (1.33) = 13.017, $p = .001$ $\eta^2 = .283$. Thus, women and men displayed a completely different gaze-behavior toward the W-related and NW-related AOIs, regardless of the sort of avatar that they owned.

Additional independent-samples t-tests were run to assess gender differences specifically in each assessment time condition (see figures 1 and 2). The largest significant differences between men and women were found at the second assessment time (larger-size virtual body) in Fixation Points (MD= 0.31, 95% CI [0.04, 0.58], p = .026) and Fixation Time (MD= 0.34, 95% CI [0.0, 0.66], p = .034), and especially at the third assessment time when they again owned the real-size virtual body, in both AB gaze variables: Fixation Points (MD= 0.39, 95% CI [0.12, 0.69], p = .005) and Fixation Time (MD= 0.49, 95% CI [0.20, 0.78], p = .002).





Figures 1 and 2. Gender differences in means of AB data in each assessment time condition. Error bar represents standard errors.

4. Discussion and conclusions

Our results suggest that women and men differ significantly in the use of gaze patterns toward specific body parts, and that these patterns result in different body checking behaviors. Women attended significantly more to weight-related body parts than men in all body size conditions, with greater fixation frequencies and greater proportion of fixation times, while men attended more to non-weight related body parts in all body size conditions. Interestingly, these gender differences were significantly greater in the larger-size virtual body, and especially when they owned the real-size virtual body for the second time.

The tendency among women to attend more to weight-related body parts supports previous studies that female ED patients and healthy participants tend to gaze more at self-attributed unattractive body parts [5], in contrast to other studies reporting a more general visual scanning behavior covering the whole body in healthy females [4]. As for men, they present the opposite gaze behavior, looking at non-weight-related body parts such as arms, shoulders or chest; this may imply an AB toward body parts that are more related with muscularity. The gender differences in our study may be related with different "ideals of body image" between the genders; while women show a preference for thinner bodies, men tend to desire a more muscular and lean body [14], resulting in different body image concerns and the use of different body checking strategies [6]. Our results support this idea; at all three assessment points, both men and women showed significantly increased body checking behavior toward their respective body areas of higher concern. Furthermore, in a previous study it was found that exposure to a larger-size VB elicited high body anxiety levels in healthy participants [15]. Therefore, this body checking behavior may also be enhanced by the discomfort elicited after owning the larger-size VB, especially when participants owned the real-size virtual body for the second time.

To our knowledge, this is the first study to assess gender differences in visual selective attention toward specific weight- or non-weight-related body parts while participants own a virtual avatar with different body sizes. However, some important limitations should be considered, such as the small sample size, the unequal gender distribution in the sample, and the lack of control of important variables such as BMI and body dissatisfaction. These findings constitute a step forward in the study of gender differences in body image assessment and body checking behaviors. The use of VR-HMD with eye-tracking devices add on may significantly improve future ED assessment and treatment by providing an objective, accurate measure of visual selective attention while taking advantage of the innumerable possibilities of VR.

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