

Jessie Y. C. Chen
Gino Fragomeni (Eds.)

LNCS 13317

Virtual, Augmented and Mixed Reality

Design and Development

14th International Conference, VAMR 2022
Held as Part of the 24th HCI International Conference, HCII 2022
Virtual Event, June 26 – July 1, 2022
Proceedings, Part I

1
Part I










HCI 2022
INTERNATIONAL



Springer



Body-Related Attentional Bias in Anorexia Nervosa and Body Dissatisfaction in Females: An Eye-Tracking and Virtual Reality New Paradigm

José Gutierrez-Maldonado¹ , Mar Clua i Sánchez¹,
Bruno Porras-García² , Marta Ferrer-García¹ ,
Eduardo Serrano³ , Marta Carulla³ ,
Franck Meschberger-Annweiler¹ , and Mariarca Ascione¹ 

¹ Department of Clinical Psychology and Psychobiology,
University of Barcelona, Passeig de la Vall d'Hebron, 171,
08035 Barcelona, Spain
jgutierrezm@ub.edu

² Department of Population Health Sciences, School of Medicine,
University of Utah, 295 Chipeta Way, Room 1N490, Salt Lake City,
UT 84108, USA
bruno.r.porras@hsc.utah.edu

³ Department of Child and Adolescent Psychiatry and Psychology,
Hospital Sant Joan de Déu, Passeig de Sant Joan de Déu, 2,
Esplugues de Llobregat, 08950 Barcelona, Spain
eserrano@sjdhospitalbarcelona.org

Abstract. According to recent research, eating disorder (ED) patients tend to check unattractive body parts. However, few studies have studied this attentional bias (AB) phenomenon combining virtual reality (VR) with eye-tracking (ET). This study aims to examine whether anorexia nervosa (AN) patients have a longer fixation time and a greater fixations number on the weight-related body areas compared to the healthy sample with high body dissatisfaction (HBD) and low body dissatisfaction (LBD). It will also examine whether the HBD group will have more fixations and spend more time looking at weight-related areas than those with LBD. Forty-three college women (18 with HBD and 25 with LBD) and 23 AN patients were immersed in a virtual environment and then embodied in a virtual avatar with their real body measurements and body mass index (BMI). Eye movement data were tracked using an ET device incorporated in the VR headset (FOVE). The number of fixations and the complete fixations time were registered on the weight-related areas of interest (W-AOIs) and non-weight-related areas of interest (NW-AOIs). The results showed that AN patients have a longer fixation time and a greater fixations number on W-AOIs than both HBD and LBD groups, who did not show any statistical differences in the visual selective attention to NW-AOIs and W-AOIs.

Keywords: Attentional bias · Body dissatisfaction · Anorexia nervosa · Virtual reality · Body image

1 Introduction

Anorexia nervosa (AN) is one of the most common eating disorders (ED), and its prevalence among women has increased over the previous two decades (Dahlgren et al. 2017). The peak onset of AN occurs throughout adolescence and early adulthood, with a higher prevalence in women (Treasure et al. 2020), and in higher-income groups (Boushey et al. 2001). AN is recognized as a significant cause of mortality in young people (Arcelus et al. 2011), with a high suicide rate and chronic courses: less than half of patients are fully recovered, and just 33% improve (Steinhausen 2009). This disorder is characterized by an intense fear of gaining weight, a disturbance in the way body size or weight is perceived, and obsessive symptoms consisting of intrusive thoughts about food, weight, and shape (Toro 2001).

Regarding the treatments, only 20% of ED patients seek treatment, and generally at advanced stages of the disease's course, reducing the possibilities of treating and managing the illness (Treasure et al. 2020). Frequently, AN treatment services lack the necessary equipment to deal with such a severe, long-term disorder (Hudson et al. 2007), and AN patients frequently do not respond to treatment (Herzog et al. 1992). According to Hudson et al. (2007), innovation and progress are critical to improve the treatment of AN.

Body image (BI) is a multidimensional model that is developed by the effect of various judgments that an individual makes about his or her body (Banfield et al. 1994). The dimension of body dissatisfaction (BD) includes cognitive and affective components (Banfield and McCabe 2002), and it relates to perceived overestimation of one's body size and strong negative feelings toward one's appearance (Gleaves et al. 1995; Wilhelm et al. 2018). BD is emphasized and maintained by the phenomena of body checking: the activity of continuously checking one's body, scoping selective body parts, frequently weighing oneself, and repeatedly staring in the mirror (Reas et al. 2002). Body image distortion (BID) is another core symptom of AN (Beato-Fernández et al. 2004), and it is one of the primary risk factors for the disease's development (Gaudio et al. 2014). As described in the DSM-5, AN patients see their bodies or body parts as being too fat, even if they are severely underweight (APA 2013).

Previous studies have confirmed that body checking practices and cognitions, which are currently neglected in treatment programs (Rosen 1997), may contribute to the etiology and maintenance of ED (Mountford et al. 2006). These behavioral patterns, however, are also observed in the non-clinical female population (Haase et al. 2011). It is critical to consider these signals since they may suggest pathological conduct and may result in the development of ED.

Previous research has found that it is possible to identify and convert to analyzable data this specific behavioral pattern. People with different levels of BD have different visual scanning behaviors (Gao et al. 2014). These comparisons can be made by assessing attentional bias (AB). In ED, AB refers to the tendency of paying more attention to body-related information compared to other information or stimuli (Williamson et al. 2004). Previous studies have shown this visual selective bias towards the body or food-related information in ED patients using AB assessment techniques such as the emotional Stroop paradigm, the dot probe paradigm (Lee and Shafran 2004),

or the visual research paradigm (Smeets et al. 2008). However, these paradigms have significant limitations (Lee and Shafran 2004).

AB can now be examined more accurately because of new technologies applied to the clinical field (Myers et al. 2004). Eye-tracking (ET) is a technology that measures eye movement and has been recently applied to provide insights into cognitive, social, and emotional factors related to psychopathological disorders (Kerr-Gaffney et al. 2019). Despite its popularity, ET has some limitations, such as those related to validity (Godfroid and Hui 2020; Lai et al. 2013), which are particularly pronounced regarding ecological validity (Gegenfurtner et al. 2018). New technologies, thanks to advances in gestural recognition hardware of 3D avatars in virtual reality (VR) and using VR-based embodiment techniques, can capture full-body motion to facilitate an immersive experience [e.g. the rubber hand illusion (Newport et al. 2010)] and producing the feeling that the artificial body is the participant's body, known as the paradigm of the full body ownership illusion (FBOI). Thus, by combining ET with VR, the ecological validity improves. Also, there is evidence that FBOI applied in VR produces cognitive changes in BD (Ferrer et al. 2018).

It has been demonstrated in previous studies that there are differences in eye movement patterns between AN patients and non-clinical samples with different BD levels: women with high levels of BD (HBD) showed sustained attentional maintenance to thin bodies (Gao et al. 2014), while ED patients have a longer fixation time for body areas they find unattractive (Bauer et al. 2017; Tuschen-Caffier et al. 2015), especially the stomach and hips (George et al. 2011). It is important to note that previous studies have focused on dividing areas of interest (AOIs) into attractive and non-attractive body parts. However, this is a subjective measure that can be affected by different types of errors. Alternatively, by dividing the body into weight-related areas and non-weight-related areas, the potential AB studied will be towards the areas objectively related to weight.

Currently, only a few studies examine eye movements in ED (Kerr Gaffney et al. 2019), and there are even fewer that study this variable using VR. Combining ET and VR can provide a new method to investigate AB in clinical and non-clinical individuals with BID, leading to more reliable results.

This study aims to provide further information about the differences in the AB between AN patients and healthy individuals with different levels of BD by combining these two technologies. According to previous studies, it is expected that AN patients should have a gaze pattern focused on weight-related body areas, as well as HBD individuals (lesser extent than the AN patients), compared to low levels of BD (LBD) participants, that should show a more general gaze scanning behavior of their own body. Adding the contribution of the new techniques to analyze this phenomenon, more valid conclusions can be drawn.

2 Method

2.1 Participants

A sample of 43 college women ($M_{\text{age}} = 21.12$, $SD = 1.56$, $M_{\text{BMI}} = 21.94$, $SD = 2.53$) from the University of Barcelona was recruited via social media and campus flyers, as well as 23 AN patients, 9 adults and 19 adolescents ($M_{\text{age}} = 16.54$, $SD = 4.13$, $M_{\text{BMI}} = 17.58$, $SD = 0.51$), diagnosed at the Eating Disorders Unit of the Hospital Sant Joan de Déu of Barcelona and the Hospital of Bellvitge. The exclusion criteria for healthy participants were a self-reported diagnosis of a current ED, a BMI < 17 (moderate thinness) or BMI > 30 (obesity), according to the World Health Organization (2004), or a self-reported current severe mental disorder diagnosis (e.g., schizophrenia or bipolar disorder), visual deficits that prevent exposure, epilepsy, pregnancy, or clinical cardiac arrhythmia.

The inclusion criteria for patients were a primary diagnosis of AN (DSM-5 criteria), a BMI < 19, and age of 13 years or over. Exclusion criteria included visual deficits that prevent exposure, severe mental disorder diagnosis, pregnancy, epilepsy, and clinical cardiac arrhythmia. Among the AN patients, 18 were diagnosed with a restricted AN type (AN-R), while 5 were diagnosed with purgative AN type (AN-P). Regarding clinical or subclinical comorbidity with other mental health disorders, two patients had mood-related disorders, two had a borderline personality disorder, three had anxiety disorders, one had a borderline personality disorder and post-traumatic stress disorder, one had major depressive disorder, and one had both anxiety and mood-related disorders. Eight patients were also receiving pharmacological treatment, including antidepressants (2 of them), anxiolytics (3 of them), and a combination of antidepressants and anxiolytics (3 of them). They were all enrolled in a day patient intensive treatment program at the Eating Disorder Unit, which consisted of 11-h sessions allowing them to sleep at home.

2.2 Instruments

Hardware and Software. Each participant was exposed to an immersive virtual scenario using a head-mounted display (HTC-VIVE Pro HMD) and was assigned a virtual avatar. In addition to the HTC-VIVE Pro HMD, four body trackers (two on the feet and two in the hands) were used to achieve full-body motion tracking. The moves of the head, the arms, and the feet were captured within the playing area delimited by two base stations. To induce the full-body illusion (FBI) with the virtual body, a visual-motor procedure and a visual-tactile stimulation was used. A second headset with incorporated ET systems (FOVE VR-HMD) was used to detect and register eye movements while participants viewed their virtual avatar in the virtual environment. The FOVE VR-HMD has a resolution of 2560 * 1440 pixels and creates 70 frames per second. Infrared ET sensors create 120 frames per second with an accuracy level of less than 1°.

Virtual simulations were developed by two software: the Blender 2.78.v software was used to create a 3D female avatar wearing a white t-shirt, jeans, brown shoes, and a swim cap to avoid any influence of hairstyle (see Fig. 1); and the Unity 3D 5.5.v. software was used to develop the object-oriented programming code and integrate the elements in the virtual environment, which consisted of a grey and brown empty room with a large mirror placed 1.5 m in front of the participant.

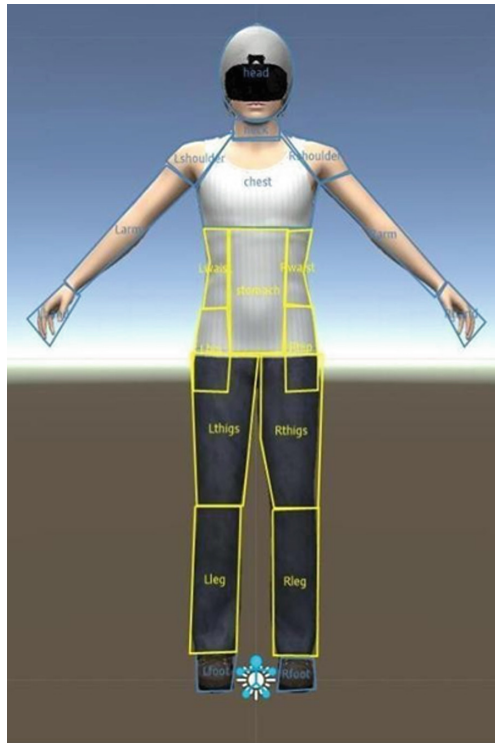


Fig. 1. Visual representation of the weight-related Areas of Interest (in yellow) and non-weight related Areas of Interest (in blue) in the virtual avatar (Color figure online)

2.3 Measures

Eating Disorders Inventory (EDI-3; Garner 2004) is a self-report inventory consisting of 12 scales and 91 items, in which the answers are provided on a 6-point Likert scale. In the current study, the Spanish version of the Body Dissatisfaction Scale (EDI-BD) was used. The EDI-BD scale, with 10 items, measures the negative subjective attitude or evaluation of one's body or specific body areas, including their shape, weight, and fitness (e.g., "I think my butt is too big"). This EDI-3 Spanish version presents robust validity and reliability indices, with a Cronbach's alpha ranging from 0.74 to 0.96. (Elosua et al. 2010).

2.4 Eye-Tracking Measures

Body-related AB was recorded by an ET device integrated into the FOVE headset, determining the participant's visual fixation on their own body. The participant's visual fixations are defined as the involuntary act of maintaining the gaze on a single location for a minimum duration, usually 100–200 ms (Jacob and Karn, 200). The measurements used in the study were the number of fixations (NF) and complete fixation time (CFT). CFT refers to the sum of the fixation time, measured in milliseconds, for the specified AOI, while NF is used to refer to the total number of fixations on the AOIs. Using the Physical Appearance State and Trait Anxiety Scale (PASTAS; Thompson 1999), two areas of interest (AOI) were defined: weight-related AOIs (W-AOIs) included waists, stomach, hips, thighs, and legs, and non-weight related AOIs (NW-AOIs) included the remaining areas. The segmentation of the AOIs was drawn in a 3D female avatar (Fig. 1). ET data was collected to obtain the records focused on W-AOIs and NW-AOIs, as used in previous studies (Mountford et al. 2006; George et al. 2011; Porras-Garcia et al. 2018).

2.5 Procedure

This study was approved by the ethics committee of the University of Barcelona. Participants or the legal guardians (if under the age of 18) had to provide informed consent before entering the study. Each participant was informed of the procedure, the data confidentiality, and the possibility of dropping out of the study at any point without consequences. Confidentiality was ensured by assigning a different identification code to each participant.

Before starting the study, the healthy participants were asked orally about their weight and height to figure out their BIM [weight (kg)/height (cm)], which was needed for the inclusion/exclusion criteria and to create a more accurate avatar for each participant's shape. For AN patients, the clinical doctors of the ED units responsible for the patients were requested information to assess the exclusion and inclusion criteria: patient's current BMI, AN subtype diagnosis, and prior history of the disorder.

To create a personalized avatar, each participant was taken a frontal and a lateral photo of the whole body by a camera connected to the computer. All participants were placed two meters from the camera standing up with their legs slightly separated and extending their arms at shoulder height. The participants completed the EDI-BD questionnaires while the researchers overlapped manually each participant's photo and virtual avatar by adapting the different dimensions of the virtual avatar (e.g., arms, legs, hip, waist, chest, stomach, breast, shoulder, etc.) to fit the silhouette of the participant.

Once ready, the participants were exposed to the VR scenario where each participant was able to observe himself in the first-person perspective and to look at himself in the mirror (in the third-person perspective). Then, a visual-motor and a visual-tactile stimulation were done to evocate the FBI by increasing identification with the virtual avatar, and the feeling that the virtual body was the participants' own body. The visual-motor stimulation procedure consisted of synchronizing the movement of the participant with that of the avatar using motion capture sensors placed on the hands and feet (e.g., "move your left arm doing little circles in front of you", "pretend that you are

walking without moving from your position”, etc.). The visual-tactile stimulation procedure consisted of synchronizing participants’ visual and tactile stimulations: while the different areas of the body (arms, legs, and stomach) were touched on the participant, each participant observed the same areas being touched on the avatar at the same time by a tactile controller of the HTC- VIVE Pro. Both procedures lasted for 1 and a half minutes.

Finally, to assess the body-related AB the HTC-VIVE Pro HMD was replaced with the HMD FOVE ET headset that displayed the same virtual room as that in the previous VR environment, with the participant’s real-size avatar reflected in the mirror. After the calibration and validation procedure of HMD-FOVE-ET, participants were instructed to gaze at the avatar reflected in the mirror for 30 s while spontaneous eye movements were recorded. As a cover story, they were told to remain still while the virtual avatar position was being recalibrated; this was necessary to avoid any bias in the participants’ gaze orientation due to knowledge of the real objective and was only explained after the completion of the procedure.

2.6 Statistical Analysis

The Open Gaze and Mouse Analyzer (OGAMA) software were used to transform the ET raw data into suitable quantitative data. An additional data transformation was conducted by subtracting the difference between W-AOI and NW-AOIs (e.g., in fixation points: 25 (W-AOIs) $- 10$ (NW-AOIs) $= 15$). Therefore, a positive outcome would mean that the participant had been looking more at the weight-related body parts than at the non-weight-related body parts, while a negative outcome would mean the opposite. It is important to note that if there is a tendency it does not imply the existence of an attentional bias.

The healthy sample was divided into high versus low BD levels using the median score of the EDI-BD as a cut-off point ($Me_{BD} = 8$). All participants with a score equal to or less than the median were classified in the low body dissatisfaction group. Since several healthy participants scored at the median value, this resulted in a different sample size in the high and low body dissatisfaction groups, with a higher number in the low than in the high group. This distribution seemed more valid to us than assigning the same number of participants to each of the two groups into which the sample of healthy participants was divided, since this would have required that some participants whose score were equal to the median of the distribution had been classified in the low body dissatisfaction group and others, with the same score, would have been classified in the high body dissatisfaction group.

All the statistical analyses were performed using the software IBM SPSS v.26. One-way between-groups analysis of variance (ANOVA) was conducted to determine if there was a difference between the three different groups (AN, HBD, and LBD participants) in the attentional bias measures (NF and CFT). Data were normally distributed in all the variables assessed by the Kolmogorov-Smirnov test, except for the LBD group. However, one-way ANOVA has performed anyway since it has been considered a robust test even in the case of a deviation from normality (Schmider et al 2010).

3 Results

3.1 Descriptive Results

Participants were classified into three groups: AN patients (n = 23), healthy participants with HBD (n = 18), and healthy participants with LBD (n = 25). The descriptive analysis of ET data related to CFT and NF is shown in Table 1. Regarding the EDI- BD scale, the AN patients showed a score of BD = 24.03, women with LBD = 4.04, and women with HBD = 14.61.

Table 1. Descriptive analysis of ET data

	AN (n = 23)	High BD (n = 18)	Low BD (n = 25)
Measure	Mean (SD)	Mean (SD)	Mean (SD)
CFT	7,190.79 (7180.13)	965,56 (7578,91)	-2,858.48 (10589.35)
NF	22.00 (12.99)	5.22 (15.49)	2.20 (15.88)

Note: Body Dissatisfaction (BD), Anorexia Nervosa (AN), Complete Fixation Time (CFT), Number of Fixations (NF)

3.2 Visual Selective Attentional Bias

A statistically significant difference ($p < .05$) between the groups on both ET variables was found: for CFT $F(2,64) = 8.258$, $p < .001$, partial $\eta^2 = 0.20$; and for NF $F(2,64) = 12,297$, $p < .001$, partial $\eta^2 = 0.27$. The effect size between groups was medium in both ET variables according to Cohen (1988). Descriptive analysis show that CFT scores increased from the LBD ($M = -2858,48$, $SD = 10589,35$) to the HBD ($M = 965,56$, $SD = 7578,91$) and to AN patients ($M = 7190,97$, $SD = 7180,13$) groups, in that order. Similarly, NF score increased from the LBD ($M = 2,20$, $SD = 15,88$) to the HBD ($M = 5,22$, $SD = 15,48$) and to AN patients ($M = 22,00$, $SD = 12,99$) groups, in that order (see Table 1). Tukey post hoc analysis revealed that the difference between LBD group and AN patients in the CFT variable was statistically significant ($p < .001$), as well as the difference between LBD group and AN patients ($p < .001$), and between HBD group and AN patients in the NF variable ($p = .002$) (see Table 2).

Table 2. Post hoc analyses (pairwise comparison) between groups in ET data

	LBD vs. HBD			AN vs. LBD			AN vs. HBD		
	Mean deviation (SD)	p	d^{cohen}	Mean deviation (SD)	p	d^{cohen}	Mean deviation (SD)	p	d^{cohen}
CFT	-3824.03 (2691.92)	0.33	0.20	10049.27 (2488.61)	<0.001*	1.11	6225.23 (2715.30)	0.64	0.84
NF	-3.02 (4.57)	0.78	0.19	19.80 (4.23)	<0.001*	1.37	16.77 (4.61)	0.002*	1.17

Note: Low Body Dissatisfaction (LBD), High Body Dissatisfaction (HBD), Anorexia Nervosa (AN), Complete Fixation Time (CFT), Number of Fixations (NF)

*Significant p values <.05.

4 Discussion

The current study aimed to assess body-related AB toward W-AOIs and NW-AOIs in women with AN and healthy participants by using an ET device for the AB measurements, a virtual idiosyncratic avatar, and an embodiment illusion. In contrast to previous studies, the AB measurements were collected using a VR headset with an ET device (FOVE), in which patients observed their own body in a virtual avatar designed specifically for them using their real BMI rather than seeing printed photographs or other people's bodies. It also differs from previous studies in the methodology used to divide the AOI into W-AOIs and NW-AOIs rather than dividing body parts based on self-reported attractive vs. unattractive criteria. Because the body attractiveness measure has been used in several AB studies (Bauer et al. 2017; Tuschen-Caffier et al. 2015; George et al. 2011), to compare this study with others the attractive areas would be considered as NW-AOIs and the unattractive areas as W-AOIs, because these areas are reported almost identically [e.g., stomach, hips and thighs as unattractive body areas (George et al. 2011)].

The results showed that AN patients had longer and more frequent gazes towards weight-related body parts than healthy participants. Between HBD and LBD groups no significant differences in the AB to body areas were found. The results observed in the AN group regarding the AB are in line with previous studies (Bauer et al. 2017; Tuschen-Caffier et al. 2015; George et al. 2011; Mountford et al. 2006; Jansen et al. 2005; Freeman et al. 1991).

The study's findings reveal that AN patients and healthy controls process information differently. One possible explanation for these findings could be that AN patients have an altered capacity of processing and integrating body representations, perceiving their body parts not in a holistic way, but in a dissociated view (Gaudio et al. 2014). This could create a vicious circle: a stronger AB to the unattractive body parts may lead to an emphasis in the negative body image, creating unfavorable cognitions and so furthering the disease (Williamson et al. 2004). These findings also support previous research (Tuschen-Caffier et al. 2015; Jansen et al. 2005; Mogg et al. 2004) that found ED patients to be hypervigilant about specific body areas that cause them dissatisfaction.

It's also crucial to consider how AN patients store body experiences in memory, particularly in sensory-motor/proprioceptive memory. According to research, AN patients have a negative allocentric view of their body, which may lead to insufficient egocentric and somatosensorial body updating, resulting in an alteration in the way they experience and remember their shape (Riva and Gaudio 2012). Furthermore, this alteration will be also associated with biased long-term memory because the orientation and position of body parts will be stored incongruously between presentation and recall (Burgess et al. 2001). These findings are supported by brain imaging studies, which show a deterioration in the areas between the parahippocampus and the precuneus in AN patients, the same areas that process an allocentric and egocentric view of the body. Body image-related cognitive biases can be manipulated (Rodgers and DuBois 2016), and according to the latest findings, VR therapy could treat biased information

processing compensating this brain malfunction as the patients see their virtual avatar in an allocentric position towards the mirror.

As young girls are more susceptible to cultural and social messages and pressures concerning the body, this alteration of the space experience may lead females, particularly adolescents, to perceive negative areas of their bodies as defining of themselves. It should also be noted that in today's Western societies the ideal body is characterized by extreme thinness, almost grazing the sick body, encouraging the female population (e.g., through the media) to maintain constant attention on the body (e.g., body checking) to keep it slim, making them more vulnerable to developing ED.

There are several limitations to this exploratory study. The first and is that the age variable was not considered. If the ED of adolescents and women were studied separately, conclusions could be drawn at these critical stages of development. Adolescents, as previously stated, have a more pronounced tendency to check body parts related to weight. No attentional bias was measured in the first point of attachment. This measurement could provide more precise information about approach-avoidance behavior. Another limitation is that women were classified as having HBD or LBD levels based on the EDI-BD median score. This is justified because the healthy sample had very similar test scores, so there were only a few extreme values.

Future research should test the possibility of modifying attentional patterns using VR technology, which could serve as an innovative therapy with ecological validity, assisting patients in becoming more conscious of their AB. It may also be used as a reference to objectively determine the improvement after therapy. Furthermore, it could be used as a preventive function in HBD females at risk of developing ED. Future initiatives should investigate this paradigm in a broader and more representative sample of AN patients and of participants with different levels of BD.

Funding. This study was funded by the Spanish Ministry of Science and Innovation (Ministerio de Ciencia e Innovación, Spain. Project PID2019-108657RB-I00: Modification of attentional bias, with virtual reality, for improving anorexia nervosa treatment) and by AGAUR, Generalitat de Catalunya, 2017SGR1693.

References

- American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders. American Psychiatric Association (2013). <https://doi.org/10.1176/appi.books.9780890425596>
- Arcelus, J., Mitchell, A.J., Wales, J., Nielsen, S.: Mortality rates in patients with anorexia nervosa and other eating disorders: a meta-analysis of 36 studies. *Arch. Gen. Psychiatry* **68**(7), 724–731 (2011)
- Banfield, S.S., McCabe, M.: An evaluation of the construct of body image. *Adolescence* **37**(146), 373–393 (2002)
- Beato-Fernández, L., Rodríguez-Cano, T., Belmonte-Llario, A., Martínez-Delgado, C.: Risk factors for eating disorders in adolescents. *Eur. Child Adolesc. Psychiatry* **13**(5), 287–294 (2004)

- Boushey, C.J., Coulston, A.M., Rock, C.L., Monsen, E.: Chapter 43: eating disorders: anorexia nervosa, bulimia nervosa and binge eating disorder. In: Rock, C.L., Kaye, W.H. (eds.) *Nutrition in the Prevention and Treatment of Disease*. Amsterdam: Elsevier (2001)
- Burgess, N., Becker, S., King, J.A., O'Keefe, J.: Memory for events and their spatial context: models and experiments. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* **356**(1413), 1493–1503 (2001)
- Dahlgren, C.L., Wisting, L., Rø, Ø.: Feeding and eating disorders in the DSM-5 era: a systematic review of prevalence rates in non-clinical male and female samples. *J. Eat. Disord.* **5**(1), 56 (2017)
- Elosua, P., López-Jáuregui, A., Sánchez-Sánchez, F.: *Adaptación Española del Eating Disorder Inventory-3. Normalización y Validación*. TEA, Madrid (2010)
- Ferrer, M.F.G., Porras Garcia, B., Moreno, M., Bertomeu, P., Gutiérrez Maldonado, J.: Embodiment in different size virtual bodies produces changes in women's body image distortion and dissatisfaction. *Annu. Rev. Cyberther. Telemed.* **16**, 111–117 (2018)
- Freeman, R., Touyz, S., Sara, G., Rennie, C., Gordon, E., Beumont, P.: In the eye of the beholder: processing body shape information in anorexic and bulimic patients. *Int. J. Eat. Disord.* **10**(6), 709–714 (1991)
- Gao, X., Deng, X., Yang, J., Liang, S., Liu, J., Chen, H.: Eyes on the bodies: an eye tracking study on deployment of visual attention among females with body dissatisfaction. *Eat. Behav.* **15**(4), 540–549 (2014)
- Garner, D.M.: *Eating Disorder Inventory-3 (EDI-3). Professional Manual*. Psychological Assessment Resources, Odessa, FL (2004)
- Gaudio, S., Brooks, S.J., Riva, G.: Nonvisual multisensory impairment of body perception in anorexia nervosa: a systematic review of neuropsychological studies. *PLoS ONE* **9**(10) (2014)
- George, H.R., Cornelissen, P.L., Hancock, P.J., Kiviniemi, V.V., Tovee, M.J.: Differences in eye-movement patterns between anorexic and control observers when judging body size and attractiveness. *Br. J. Psychol.* **102**(3), 340–354 (2011)
- Gleaves, D.H., Williamson, D.A., Eberenz, K.P., Sebastian, S.B., Barker, S.E.: Clarifying body-image disturbance: analysis of a multidimensional model using structural modeling. *J. Pers. Assess.* **64**(3), 478–493 (1995)
- Godfroid, A., Hui, B.: Five common pitfalls in eye-tracking research. *Second Lang. Res.* 026765832092121 (2020)
- Haase, A.M., Mountford, V., Waller, G.: Associations between body checking and disordered eating behaviors in nonclinical women. *Int. J. Eat. Disord.* **44**(5), 465–468 (2011)
- Herzog, D.B., Keller, M.B., Zucker, M.E., Strober, M., Yeh, C., Pai, S.Y.: The current status of treatment for anorexia nervosa and bulimia nervosa. *Int. J. Eat. Disord.* **12**(2), 215–220 (1992)
- Hudson, J.I., Hiripi, E., Pope, H.G., Jr., Kessler, R.C.: The prevalence and correlates of eating disorders in the national comorbidity survey replication. *Biol. Psychiat.* **61**(3), 348–358 (2007)
- Kerr-Gaffney, J., Harrison, A., Tchanturia, K.: Eye-tracking research in eating disorders: a systematic review. *Int. J. Eat. Disord.* **52**(1), 3–27 (2019)
- Lai, M.L., et al.: A review of using eye-tracking technology in exploring learning from 2000 to 2012. *Educ. Res. Rev.* **10**, 90–115 (2013)
- Lee, M., Shafran, R.: Information processing biases in eating disorders. *Clin. Psychol. Rev.* **24**(2), 215–238 (2004)
- Mogg, K., Bradley, B., Miles, F., Dixon, R.: Brief report time course of attentional bias for threat scenes: testing the vigilance-avoidance hypothesis. *Cogn. Emot.* **18**(5), 689–700 (2004)
- Mountford, V., Haase, A., Waller, G.: Body checking in the eating disorders: Associations between cognitions and behaviors. *Int. J. Eat. Disord.* **39**(8), 708–715 (2006)

- Myers, T.C., Swan-Kremeier, L., Wonderlich, S., Lancaster, K., Mitchell, J.E.: The use of alternative delivery systems and new technologies in the treatment of patients with eating disorders. *Int. J. Eat. Disord.* **36**(2), 123–143 (2004)
- Newport, R., Pearce, R., Preston, C.: Fake hands in action: embodiment and control of supernumerary limbs. *Exp. Brain Res.* **204**(3), 385–395 (2010)
- Reas, D.L., Whisenhunt, B.L., Netemeyer, R., Williamson, D.A.: Development of the body checking questionnaire: a self-report measure of body checking behaviors. *Int. J. Eat. Disord.* **31**(3), 324–333 (2002)
- Riva, G., Gaudio, S.: Allocentric lock in anorexia nervosa: new evidences from neuroimaging studies. *Med. Hypotheses* **79**(1), 113–117 (2012)
- Rodgers, R.F., DuBois, R.H.: Cognitive biases to appearance-related stimuli in body dissatisfaction: a systematic review. *Clin. Psychol. Rev.* **46**, 1–11 (2016)
- Schmider, E., Ziegler, M., Danay, E., Beyer, L., Bühner, M.: Is it really robust?: reinvestigating the robustness of ANOVA against violations of the normal distribution assumption. *Methodology* **6**(4), 147–151 (2010). <https://doi.org/10.1027/1614-2241/a000016>
- Smeets, E., Roefs, A., van Furth, E., Jansen, A.: Attentional bias for body and food in eating disorders: increased distraction, speeded detection, or both? *Behav. Res. Ther.* **46**(2), 229–238 (2008)
- Steinhausen, H.C.: Outcome of eating disorders. *Child Adolesc. Psychiatr. Clin. N. Am.* **18**(1), 225–242 (2009)
- Thompson, J.K.: *Physical Appearance State and Trait Anxiety Scale: Trait 1996*. APA, Washington, DC (1999)
- Toro, J.: Anorexia nervosa. *Med. Clin.* **117**(9), 334–335 (2001)
- Treasure, J., Duarte, T.A., Schmidt, U.: Eating disorders: innovation and progress urgently needed. *Lancet* **395**(10227), 840 (2020)
- Tuschen-Caffier, B., Bender, C., Caffier, D., Klenner, K., Braks, K., Svaldi, J.: Selective visual attention during mirror exposure in anorexia and bulimia nervosa. *PLoS ONE* **10**(12), e0145886 (2015)
- Wilhelm, L., Hartmann, A., Cordes, M., Waldorf, M., Vocks, S.: How do you feel when you check your body? Emotional states during a body-checking episode in normal – weight females. *Eating and Weight Disorders – Studies on Anorexia, Bulimia and Obesity* **25**(2), 309–319 (2018)
- Williamson, D.A., White, M.A., York-Crowe, E., Stewart, T.M.: Cognitive – behavioral theories of eating disorders. *Behav. Modif.* **28**(6), 711–738 (2004)