LNCS 14027

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# Virtual, Augmented and Mixed Reality

15th International Conference, VAMR 2023
Held as Part of the 25th HCI International Conference, HCII 2023
Copenhagen, Denmark, July 23–28, 2023
Proceedings

HCI 2023 INTERNATIONAL

Springer

# Treatment of Anorexia Nervosa Through Virtual Reality-Based Body Exposure and Reduction of Attentional Bias

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**Abstract.** Anorexia nervosa (AN) is a severe disorder. It has higher mortality rates than other eating disorders (ED) and is increasingly being diagnosed in younger patients. One of the main fears among individuals with AN is the fear of gaining weight (FGW). Patients with AN also display dysfunctional behaviors that aim to avoid weight gain by drastically reducing food intake, vomiting, using laxatives and diuretics, or doing intense exercises. AN patients engage in frequent conduct of checking and scrutinizing those parts of their body directly related with weight, which suggests attention focused on the body that has a dysfunctional nature. Although research on the presence of attentional biases in ED is extensive, very little has been done up to the present to apply the information gathered in those studies with the purpose of improving the efficacy of the available treatments. One of our recent projects aimed to provide evidence of the efficacy of a virtual reality-based body exposure therapy in AN in directly targeting the FGW through a randomized controlled clinical trial. We are currently developing a new clinical trial to test whether the addition of a component aimed at reducing the attentional bias towards the body serves to intensify the effect of the exposure treatment. It is expected that the reduction of the attentional bias will facilitate the control of visual avoidance behaviors during exposure sessions, increasing the efficacy of the treatment.

**Keywords:** Attentional Bias · Body Dissatisfaction · Anorexia Nervosa · Virtual Reality · Body Image


J. Y. C. Chen and G. Fragomeni (Eds.): HCII 2023, LNCS 14027, pp. 453–463, 2023.
https://doi.org/10.1007/978-3-031-35634-6_32

## 1 Introduction

Eating disorders (ED) are usually characterized by dysfunctional eating patterns and/or disordered behaviors directed towards weight control that negatively affect the person's physical and mental health. Anorexia Nervosa (AN) is specifically characterized by persistent food intake restriction, an intense fear of gaining weight, and a dysfunctional body self-perception (BIDs). These characteristics are reflected in a refusal to maintain body weight at least at a minimally normal level, which in turn results in high rates of morbidity and mortality.

AN is a severe disorder, affecting approximately 1–4% of women and 0.3–0.7% of men [1]. It has higher mortality rates than other eating disorders (ED), and is increasingly being diagnosed in younger patients, with a typical age of onset of around 14 and 19 years. One of the main fears among individuals with AN is the fear of gaining weight (FGW); an overconcern of the possibility of gaining weight in the whole body or in some specific body parts. Patients with AN also display dysfunctional behaviors that aim to avoid weight gain by drastically reducing food intake, vomiting, using laxatives and diuretics, or doing intense exercises.

Several therapies have been recommended for the treatment of AN; Cognitive Behavioral Therapy (CBT) is recommended in several international guidelines for the psychological management of patients with ED. Other alternatives also supported by the available literature would be interpersonal psychotherapy or family-based treatment, the last one specially indicated for teenagers. However, there is a significant number of ED patients that do not improve after treatment, and this is particularly relevant for those with AN; they have lower rates of recovery and experience fewer long-term effects on weight gain or psychological symptom improvements than other ED patients. This increased difficulty in the recovery of AN means that it is still necessary to either search for better alternatives to the interventions that are currently in use or to look for ways to improve them.

Patients with AN frequently experience anxiety and avoidance behaviors (such as food restriction) in response to certain stimuli (such as food or their own bodies). As a result, incorporating components that target the anxiety experienced by patients in relation to eating and weight gain can strengthen the treatment of AN. It is for this reason that exposure techniques have been proposed as an effective treatment for this disorder. Exposure techniques are included frequently in the treatment of anxiety and related disorders, such as phobias, and they are often combined with other CBT components. The conceptualization of some of the core elements of AN can effectively explain the rationale of the addition of exposure therapy to the treatment of this disorder. As mentioned earlier, two of the core aspects of AN are BIDs and FGW. There is a possible explanation that links these two factors: the over-evaluation of weight and shape would come from the fear of imagined negative outcomes or consequences resulting from violating the thin ideal (such as being seen as disgusting, being rejected, or losing control). This belief of the negative consequences of gaining weight would come with safety and compulsive behaviors around eating and the body that appear in EDs. In AN, the restricted food intake would momentarily reduce the anxiety generated by the FGW, thus reinforcing the avoidance behavior (in this case, restriction). The fear and anxiety processes are a driving force for the problematic behaviors that maintain disordered eating. Another reason to pay special attention to these elements is that BIDs frequently persist even after treatment and recovery, and they are reliable predictors for relapse.

There are several treatments in which different forms of exposure are included as components. Among the exposure-based procedures using body image cues, mirror exposure therapy (MET) has been widely used, reducing negative body-related emotions and cognitions through habituation [3]. In severe cases of AN, in-vivo mirror exposure techniques may be contraindicated, due to the risk of eliciting habituation toward a very skinny body shape.

Imaginal exposure might help patients with AN confront their core FGW, which is impractical to do with in-vivo exposure. However, some patients who undergo imaginal exposure might report difficulties maintaining a visualization over time, due to attentional fatigue, and may also display avoidance-based strategies while they imagine a progressive weight gain. The application of virtual reality (VR) offers an innovative solution to these problems since it does not rely on the visualization ability of the patient. In addition, this technology can significantly reduce avoidance-based behaviors by using eye-tracking (ET) devices to control the patient's gaze patterns towards their own body.

Some studies have connected BIDs with the presence of attentional bias (AB), and even suggested that this connection may be bidirectional. AN patients engage in frequent conduct of checking and scrutinizing those parts of their body directly related with weight, which suggests attention focused on the body that has a dysfunctional nature. Analyzing attentional biases related with specific parts of the body, several studies have found that patients with ED, and particularly those with AN, pay more attention to the parts of their own body that they define as unattractive, while individuals who do not have ED show a broader distribution of attention, that is unbiased, and includes the entire body [2]. Biased attention to body stimuli has been shown to influence the development and maintenance of ED symptoms and is a mediator of the relationship between body mass index and body dissatisfaction. Also, body-related AB may reduce the efficacy of body exposure therapy in patients with AN. Hence, this leads to turning the modification of AB into a potentially important target, as it can directly affect BIDs and improve the efficacy of current treatments.

Numerous methods have been used to assess attention bias in patients with ED. The most frequent are based on modified Stroop tasks, dot-probe, visual search and eye-tracking (ET). Albeit to a lesser extent, other methods have been used, such as dichotic listening tasks, lexical decisions and spatial signaling. Of all of these techniques, ET is the only one with which it is possible to record a continuous measurement of attention devoted to different stimuli. On another note, and with few exceptions, most cognitive tasks involve verbal stimuli, while ET techniques facilitate analysis of behavior most directly related with the stimuli that in natural situations trigger the dysfunctional responses. Therefore, this technique facilitates the objective, direct measurement of attention biases, while with cognitive tasks, such as those previously mentioned, those biases can only be inferred through response latencies.

Although research on the presence of attentional biases in ED is extensive, very little has been done up to the present to apply the information gathered in those studies with the purpose of improving efficacy of the available treatments.

One of our recent projects aimed to provide evidence of the efficacy of a VR body exposure therapy in AN in directly targeting the FGW through a randomized controlled clinical trial [4]. We are currently developing a new project to test whether the addition of a component aimed at reducing the attentional bias towards the body serves to intensify the effect of the exposure treatment. It is expected that the reduction of the attentional bias will facilitate the control of visual behaviors during exposure sessions, increasing the efficacy of the treatment.

To bring about a reduction in attentional bias, we apply a training based on an adaptation of the Smeets, Jansen and Roefs [5] bias induction procedure. This procedure has proven its efficacy in triggering changes in the attentional biases of participants with varying levels of body dissatisfaction. The procedure is adapted to produce a reduction of the bias, instead of a bias induction toward any given parts of the body. Therefore, the result is a balanced distribution of attention among the different parts of the body. Furthermore, the procedure is adapted for use with VR devices featuring built-in ET devices, so that the training is carried out while the patient observes an avatar through immersive VR that is a simulation of their own image reflected in a virtual mirror.

The synergies between these two technological resources offer opportunities of great interest to study, through objective indicators (such as those offered by ET instruments) in highly-controlled situations and with high ecological validity (such as those that can be achieved with VR techniques) of basic processes that are altered in eating disorders, and in a relevant manner for the design of new treatment components that could enable an improvement in the efficacy of the interventions currently available for eating disorders, especially anorexia nervosa.

Based on the relationships between FGW, BIDs, and AB, it is possible to hypothesize that by decreasing the AB, there will be a strengthening of the effects of the interventions to decrease both FGW and BIDs. While this will have to be repeatedly contrasted in the future, with samples of patients, the current study aims to verify the observed AB decrease after a body-related AB modification training intervention using ET and VR technology in healthy individuals. The body-related AB modification training is based on a VR exposure to the person's own body (simulated with a virtual avatar) with a task designed to alter AB by forcing the participants to look at the different parts of the body for an equal amount of time, in order to habituate them to this pattern of looking at their body. The hypothesis is that, after this task, the AB values would become more balanced, that is, the participants will spend an equal amount of time looking at weight-related and non-weight-related body areas. If this attentional bias reduction procedure were effective, it could be used in the treatment of patients with anorexia nervosa.

## 2 Method

### 2.1 Participants

The participants were psychology students (Universitat de Barcelona) who accepted to participate in the experiment. The study was approved by the bioethics committee of the University of Barcelona. The initial number of participants was 108. Since some studies have indicated a possible gender difference in the expression of AB [4]. And the sample was mostly female, it was decided for men to be excluded (totaling 17), thus resulting in a sample of 91 adult women. Those participants with missing data were not taken into account, which left a final working sample of 80 adult women.

Exclusion criteria were severe mental disorders with psychotic or manic symptoms, a current diagnostic of ED, visual impairments that actively prevented or obstructed completing the tasks, and epilepsy.

## 2.2 Measures and Instruments

Eating Disorders Inventory (EDI-3; Garner, 2004) was used to obtain a measure o body dissatisfaction. EDI-3 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 subscale (EDI-BD) was used. The EDI-BD scale, with 10 items, measures the negative attitude or evaluation of one's body or specific body areas, including their shape, weight, and fitness.

Regarding the AB measures, the ET device within the VR headset recorded the gaze behavior, allowing to later derive two measures from the raw ET data: Complete Fixation Time (CFT) and Number of Fixations (NF). CFT refers to the sum of the fixation time at the specified area of interest (AOI), either weight-related (W-AOI) or non-weight-related body parts (NW-AOI), measured in milliseconds. NF is the total number of fixations in the areas of interest (again, weigh-related and non-weight-related body parts).

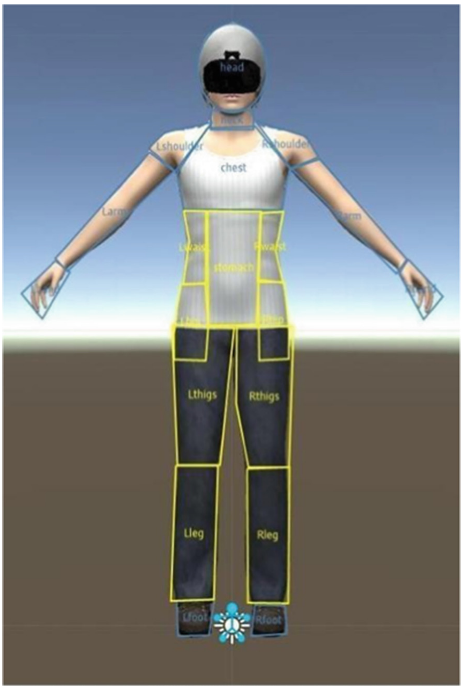


**Fig. 1.** Visual representation of the weight-related Areas of Interest (in yellow) and non-weight related Areas of Interest (in blue) in the virtual avatar. (Color figure online)

Using the Physical Appearance State and Trait Anxiety Scale (PASTAS [7]), two areas of interest (AOI) were defined: weight related AOIs, and non-weight related AOIs. The weight-related AOIs were defined as the thighs, buttocks, hips, stomach, legs, and waist, while the remaining areas were defined as non-weight-related AOIs; A visual representation of this division can be observed in Fig. 1, with the yellow forms specifying the weight-related AOIs and the blue forms delimiting the non-weight-related AOIs.

All participants used the same VR headset to complete the task: a VR HTC-VIVE PRO Eye head- mounted display (HTC Corporation, New Taipei City, Taiwan), with 2 controllers and two trackers to follow the hand movements of the participants and their feet movements. The VR training task and environment were developed in Unity 2021.x (Unity Technologies, San Francisco, CA, USA). The environment consisted of a room with a large mirror in the wall, facing the participants' avatar. Besides that, some boxes were placed on the floor, next to the avatar's feet, as neutral stimuli. The avatar was designed to have a simple white tank-top with jeans and black trainers (the top and the jeans' colors could be changed to match the participants' clothing), while the hair was covered by a hat (Fig. 2).

### 2.3 Procedure

Each participant was informed of the procedure, read, and signed the informed consent after an explanation of the usage of the data, the non-compulsory participation and that they could stop anytime they requested it. Then, weight and height measures were taken, alongside a frontal and a sideways photo, to create a virtual avatar. The researchers adjusted the avatar to have a similar silhouette to that of the participants. Once ready, the trackers and VR headset were put on the participant and calibrated. Then, visuomotor

**Fig. 2.** Avatar simulating the reflected image of the participant

and visuotactile stimulations were conducted to evocate the FBOI, feeling the virtual body as the participants' own body (Fig. 3).

**Fig. 3.** Visuomotor and visuotactile stimulation for FBOI production

Next, the first ET measures were taken, camouflaged as a calibration of the sensors to avoid any bias due to knowledge of the real objective (it was explained after the completion of the procedure). After the measurements, the attentional bias modification task (ABMT) started.

The ABMT was a VR adaptation of the procedure developed by Smeets, Jansen & Roefs [5], and it consisted of staring for 4 s at the places where geometrical figures appeared on the avatar's reflection, following this distribution: 45% of the figures appeared on non-weight related body parts, 45% appeared on weight related body parts, and the remaining 10% appeared on neutral stimuli (boxes on the floor). They repeated this search-and-stare task for 90 trials (Fig. 4).

When the ABMT finished, the ET measures were taken again. Then the VR headset and trackers were removed, and the researchers explained the concealment of the ET and cleared any remaining doubts.

**Fig. 4.** Atentional Bias Modification Task (ABMT)

### 2.4 Data Analysis

To prepare the compiled ET data for the analysis, the Open Gaze and Mouse Analyzer (OGAMA) software was used. All the following analyses were done with SPSS (version 27). 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 score 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.

The participants were divided into three groups for the analysis, based on the baseline body-related AB (CFT measures). Thus, the total sample was split in three, according to the percentile distribution of the first CFT measure: women past the percentile 75 (2133.5 ms) were assigned to the weight-related AB group (WR-AB; n = 20), those under the percentile 25 (−3183.5 ms) to the non-weight-related AB group (NW-AB; n = 20), and those with CFT values between those percentiles were put into the no AB group (n = 40).

A two-way mixed ANOVA analysis was conducted to assess whether there was a statistically significant interaction between time (pre-post ABMT assessment times) and the defined groups. Regarding the analysis for CFT, six outliers were detected by inspecting a boxplot for values greater than 1.5 box-lengths from the edge of the box, but as their values didn't significantly affect the results, it was decided to keep them for the analysis.

## 3 Results

The participants were all women, with a mean age of 23.76 years (SD = 3.52, age range: 20–41 years), and a mean Body Mass Index (BMI) of 21.77 (SD = 2.93, range: 17.40–30.94). Age and BMI were similar in the three groups: mean age NoAB group was 23.53, mean age WR-AB group was 22.95, and mean age NW-AB group was 23.32; BMI NoAB group was 21.6, BMI WR-AB group was 21.75, and BMI NW-AB group was 21.5. As expected, since attentional biases to weight body parts are associated with body dissatisfaction and other ED characteristics, some differences between the groups were found in the body dissatisfaction level (EDI-BD): the NoAB group and the NW-AB group showed similar scores (7.88 in the NoAB group and 7.05 in the NW-AB group), but the WR-AB group showed a higher score in this variable (9.84).

A statistically significant interaction between the intervention and group on CFT was found, $F(2, 73) = 7.66$, $p < .001$, partial $\eta^2 = .174$. As can be seen in Fig. 5, those groups with AB (be weight-related on non-weight-related) showed a tendency towards neutral values, that is, a reduction of the AB after the ABMT intervention.

When the simple effects of the group were explored, the pre-assessment showed statistically significant differences between all the groups as expected ($p < .001$), but after the intervention, only the groups NW-AB/WR-AB maintained a significant difference ($p = .005$), while the differences between groups NW-AB/No AB and WR-AB/No AB were not significant ($p > .05$). For the simple effects of time, the only group that showed a statistically significant difference between the two assessments was the WR-AB group ($p < .001$).

When accounting for the mixed ANOVA conducted for the NF measures, there was a significant interaction between group and time $F(2, 73) = 4.21$, $p < .019$, partial $\eta^2 = .103$. Figure 6 shows how the tendencies are similar to those seen with the CFT, with both AB groups getting closer to the No AB group after the intervention.

Regarding the simple effects of the group, the results mimic those from the CTF: while the differences are statistically significant between the groups during the first

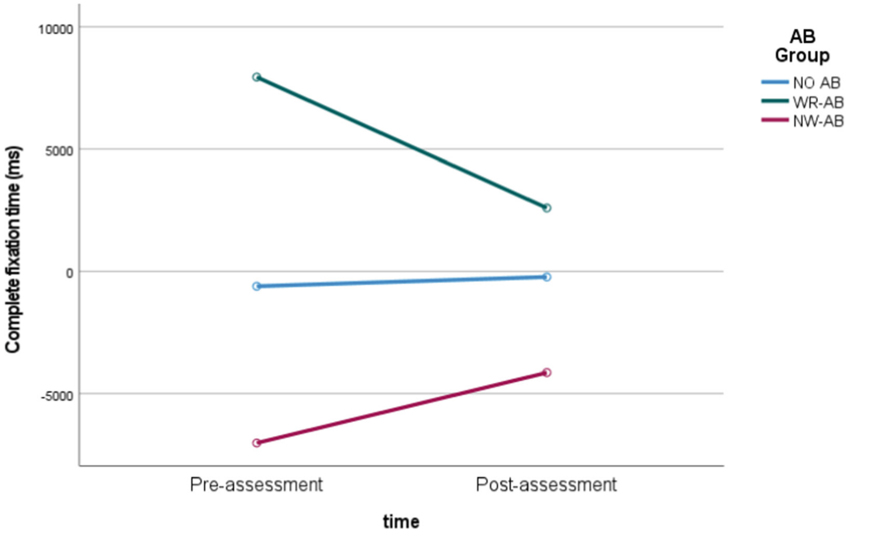


**Fig. 5.** CFT time*group interaction. Pre-assessment is the CFT before the ABMT, and Post-assessment is the CFT after the ABMT

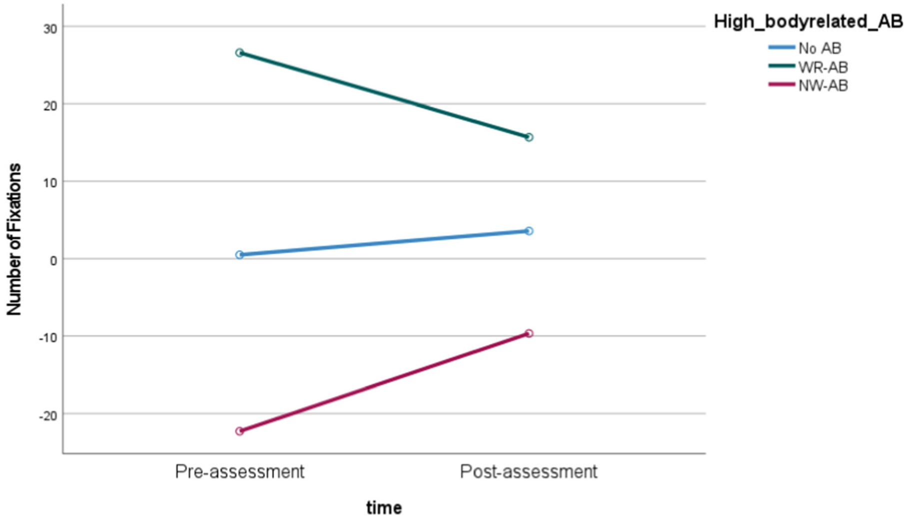


**Fig. 6.** NF time*group interaction. Pre-assessment is the NF before the ABMT, and Post-assessment is the NF after the ABMT

assessment (p $<$ .001), the only statistical significance maintained after the ABMT intervention is the one between the WR-AB and NW-AB groups (p = .005). For the simple effects of time, the NW-AB group is the only one with a statistically significant difference ($p < .05$) between the two assessment points, while the WR-AB group showed a marginally significant difference ($p = .058$).

## 4 Discussion

ET measures showed significative group*time interactions, showing that the VR intervention was able to reduce the attentional bias. This happened for the CFT as well as for the NF measures, indicating that the participants showed a tendency towards the neutral values after the task (looking equally at both weight-related and non-weight related body parts).

A point that needs more research is the nature of the AB. While we assessed the CFT and assigned the groups based on the body parts that the participants looked at the most, there was not a differentiation between the reasons behind the AB. In some cases, paying more attention to some parts of the body than others may be because those parts are more to her liking. In other cases, the increased attention may be due to avoiding the other parts, because they are not pleasant to her. Also, the increased attention may come from scrutiny of the least liked parts. These possible distinctions were not considered when assigning the groups for the analysis, but there is a possibility that some variability in the results may stem from this. Something can be derived from the EDI-BD descriptives: albeit it wasn't a huge difference, those who had the highest scores on body dissatisfaction were in the WR-AB group. This was expected, since attentional biases to weight body parts are associated with body dissatisfaction and other ED-like characteristics, even in healthy individuals. Thus, it could be thought that those in the WR-AB group showed a tendency to pay more attention on the parts of their body that they do not like, and, therefore, their AB would be the result of scrutiny behaviors.

This study has some limitations. The silhouette was adjusted to be similar to the participant's, but there were many aspects of the avatar that didn't look alike (the most obvious differences stemmed from the only personalization available for the clothes being the option to change colors, or the hair of the avatar being covered with a grey beanie for all participants), and this could very well be an impediment for the participant to identify the avatar as his own body, which can be relevant for these interventions. Another important limitation is suggested by comments from some participants, who indicated that they found the attentional bias modification task too long and boring after the first few trials. Anticipating that this could happen, different types of geometric figures were used in the design of the task, which could also vary in color. However, it would be necessary to explore in future studies other ways of maintaining the motivation to perform the task. One possibility would be to gamify it, proposing objectives and offering rewards for reaching them. Another possibility would be to study the minimum duration of the task to obtain the results sought in reducing attentional bias, so that the participants performed only the necessary and sufficient number of trials to do so, without prolonging the task beyond what was strictly necessary.

The results of this study show that the task designed to reduce attentional biases towards the body is effective when applied to healthy individuals. In a subsequent phase, it would be necessary to verify if this efficacy is also demonstrated when applied to patients with AN. If so, this training in reducing attentional bias towards certain parts of the body could be incorporated as a component in the treatments currently used to intervene on this disorder. For example, as a preliminary phase in order to increase the effect of the exposure to the body. However, before moving on to studies with patients, it would be necessary to improve some aspects of the task, to establish the minimum time necessary to achieve the bias reduction effect without producing fatigue that could reduce adherence to treatment or its effectiveness.

**Funding.** This study was funded by the Spanish Ministry of Science and Innovation (Agencia Estatal de Investigación, Ministerio de Ciencia e Innovación, Spain). Grant PID2019-108657RB-I00 funded by MCIN/AEI/10.13039/501100011033.

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