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# Manipulating body size distortions and negative body-related memories in patients with Anorexia Nervosa: A virtual reality-based pilot study

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**Abstract.** The Allocentric Lock theory (ALT) suggests that anorexia (AN) may be the outcome of a primary disturbance in the way the body is “experienced” and “remembered”. A long tradition of research had proved that emotions can influence the encoding, storing and retrieving of memories. The aim of the present study was to explore the effectiveness of a new virtual reality (VR) paradigm combining the autobiographical recall and the body-swapping techniques in order to unlock the allocentric memory of the body in patients with AN. Seven young women diagnosed with AN following DSM-5 criterion, participated in this study. Before and after the experimental sessions, patients underwent pre-post assessment battery in which cognitive, affective and perceptual variables related with their clinical condition were assessed. The VR-based protocol consisted in four sessions in which patients were immersed in an avatar from an egocentric and an allocentric perspective. The body mass index (BMI) of the avatar was increased throughout the VR sessions: starting from patient’s BMI until reaching the normal weight. During each session patients were asked to indicate their real and ideal BMI and to recall negative and positive life events. Patients showed lower negative emotions and body shame at fourth session compared to baseline. Furthermore, patients showed an increase in body satisfaction and an improvement in the accuracy of body perception and body shape. This new VR paradigm might be an effective tool for both assessment and treatment of body perception in AN.

**Keywords.** Anorexia Nervosa, Virtual Reality, Autobiographical Recall, Body Swapping

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## 1. Introduction

Body image disturbance (BID) affects body-related feeling, thoughts, perceptions and behaviors. BID had been recognized as a clinical feature of critical importance in the development and maintenance of anorexia nervosa (AN) [1,2]. As yet, the mechanisms underlying BID remain unclear. The Allocentric Lock theory (ALT) [3] suggests that AN may be the outcome of a primary disturbance in the way the body is “experienced” and “remembered”. Specifically, this theory suggests that individuals with AN have an impairment in the ability to update the memory of the body based upon the allocentric representation with new contexts from real-time perception (egocentric representation) [4-6]. According to ALT, impairments in specific aspects of memory function prevent the updating of the self-concept, locking patients with AN in a negative long-term memory of their body (e.g. I’m fat). Increasing evidence has shown that emotions can influence memory by modulating the encoding, storing and retrieving memories, as well as the consolidation of memory traces [7]. Memory retrieval can lead the person to relive specific mental states connected to the event, as emotions, thoughts and desires. In light of this, retrieving significant events, such as body-related events, through an emotional induction able to connect body memory to specific emotions could provide changes in the memory of the body. In the last two decades, researchers have relied on virtual reality (VR) to integrate and extend the assessment tools and treatments for many psychological disorders, including BID [8-10]. In the present study we propose a new VR paradigm combining an emotional induction technique, the autobiographical recall technique, [11] and a VR procedure, body-swapping, [12] to unlock the allocentric memory of the body in patients with AN. The aim of the study is to explore the effectiveness of a new VR paradigm in AN on the perceptual and symptomatologic dimensions. We hypothesized that, after VR intervention, participants would show an increased body satisfaction and body estimation accuracy as well as a decreased body shame and concerns about body image.

## 2. Materials and Methods

### 2.1. Participants

Seven young women diagnosed with AN participated in this study (age =  $17 \pm 1,87$ ; BMI =  $15,95 \pm 0,61$ ). Patients were recruited from the Eating Disorders Centre, San Luca Hospital in Milan. Inclusion criteria envisaged to meet the diagnostic criteria for AN based-on DSM 5 and a BMI not under 15. Exclusion criteria included current or prior history of a neurological illness, brain damage and psychiatric comorbidity. All participants were informed about the purpose of the research and provided written informed consent. The study was approved by the local ethical committee of the Istituto Auxologico Italiano.

## 2.2. Measures

In order to evaluate the perceptual dimension, the VR body size estimation task [13] and the embodiment questionnaire [14] were administered. During the VR body size task, participants were asked to verbally indicate how to modify the size of the virtual body in order to match it with their ideal body size and with their perceived real body size. The BMI of the avatar could be changed from 42.5 to 12.5. Furthermore, an adapted version of 10 item self-reported embodiment questionnaire [14] was used to evaluate the ability of VR to induce a sense of ownership over the avatar, after each virtual condition. The questionnaire assesses three embodiment components, ownership, agency and location through a 7-point Likert response scale. As regards the clinical assessment, the body satisfaction scale (BSS) [15], the body shape questionnaire (BSQ) [16] and the objectified body consciousness scale (OBCS) [17] were administered pre and post intervention.

## 2.3. Procedure

Before and after the VR intervention, participants underwent a pre-post assessment battery in which affective and perceptive variables related with their clinical condition were assessed by the experimenter, a clinical psychologist, using questionnaires. The VR intervention included a head-mounted display connected to a laptop computer and a motion tracker device, a Microsoft Kinect sensor, through which participants were immersed in a virtual environment and fully embodied in a virtual body. The protocol consisted in four sessions in which participants were immersed in an avatar from an egocentric and an allocentric perspective. This immersive experience led to the body swapping illusion induced through visuo-motor synchronization between the real's participants body and the virtual body. Every session started with an embodiment phase in which participants were asked to align their real body with the virtual avatar and to slowly move the legs and the arms. Then, participants were asked to observe the synchronization between the movement of the real legs and arms with the virtual body. This phase aimed at inducing the embodiment toward the virtual body using synchronous visuo-motor correlations. The body mass index (BMI) of the virtual body was increased throughout the VR sessions: in session one and two the BMI of the avatar corresponds to the participant's real BMI (underweight), in session three avatar's BMI increased to 17.5 and in the final session it increased to 18.5 (healthy BMI). Participants were asked to recall unpleasant life events while they were immersed in the low BMI and positive life events while they were immersed in the normal BMI following a classical autobiographical recall procedure. The aim was to help patients associate negative feelings to the underweight BMI and the positive memories to the normal BMI. Finally, during each session, participants were asked to estimate their real and ideal body size with the virtual reality body size estimation task [13]. The experimenter modified the avatars' BMI through the VR computer interface accordingly.

## 2.4. Results

As regards the VR body estimation task, a Delta index was calculated between the perceived real body and the real body and between the ideal body and the real body (BMI real). With these outcomes we conducted a Mann-Whitney non parametrical test to compare the perceptual distortions of the real and ideal body size. Moreover, we carried out Wilcoxon Signed Rank test for a pre-post treatment evaluation of the clinical measures. As regards embodiment questionnaire, participants reported significantly higher levels of ownership ( $z=4.98$ ,  $p<0.0001$ ), location ( $z=-2.27$ ,  $p=0.023$ ), and agency ( $z=-2.05$ ,  $p=0.041$ ) over the virtual body when they embodied the avatar with their *perceived* real BMI, than when they embodied the avatar with their *desired* BMI. Regarding the VR size estimation task, participants showed an improvement in the estimation of the desired BMI from session 1 to session 4 (Fig. 1). In the clinical assessment, results showed a reduction in body

dissatisfaction from session 1 to session 4 (Fig.2). Furthermore, with a pre-post evaluation, results showed decreased concerns about body image (Fig. 3) and body shame (Fig.4), although not significant.

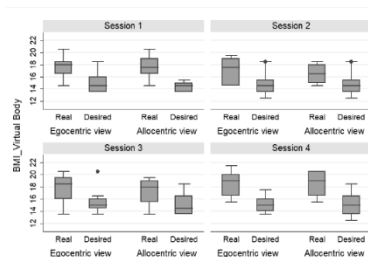


Figure 1. VR body size estimation.

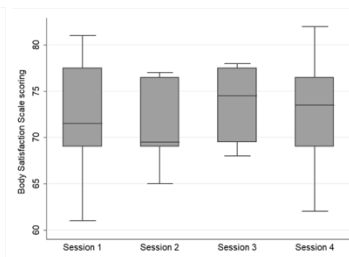


Figure 2. Body satisfaction scale.

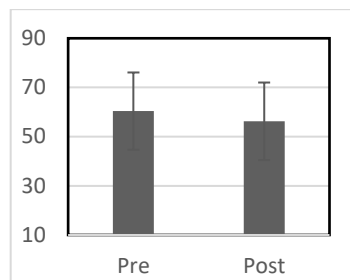


Figure 3. Body shape questionnaire.

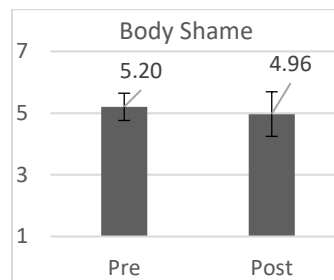


Figure 4. Objectified Body consciousness Scale.

### 3. Discussion and conclusions

We conducted a pilot study to evaluate a new VR paradigm combining the autobiographical recall technique [11] and the body-swapping intervention [12] to modify the negative memory of the body in subjects with AN. The results showed that after the VR intervention participants reported a trend of decreasing level of general body dissatisfaction [18], concerns about body image and body shame. Furthermore, results from BSS indicated that the autobiographical recall technique together with VR body swapping could modulate patients' body satisfaction after VR exposure. The VR exposure combined with the positive and negative autobiographical recall reduced the satisfaction after the negative recall in session two, that increase after session 4. According to ALT, these findings suggest that the manipulation of the emotional state could change the allocentric memory of the body. Furthermore, regarding the perceptual assessment, results showed that participants reported higher level of embodiment when they were immersed in the avatar with the perceived real body size, rather than the desired body size. This result was in line with a previous study [19] indicating VR paradigm as an effective tool to assess and modify body distortion in AN. Finally, regarding the virtual body size estimation, our results showed that after the VR intervention, participants desired a body that was closer to a normal BMI than the pathological size. This can be a promising and interesting finding, which could stem from the combination of the emotional and perceptual intervention.

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