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A Healthy Mind in a Healthy Virtual Body: The Future of Virtual Reality in Health Care

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Contents

Does owning a "fatter" virtual body increase body anxiety in college students?

Marta FERRER-GARCIA[a*], Bruno PORRAS-GARCIA[a], Cristina GONZÁLEZ-IBAÑEZ[a], Mireia GRACIA-BLANES[a], Ferran VILALTA-ABELLA[a], Joana PLA-SANJUANELO[a], Giuseppe RIVA[b], Antonios DAKANALIS[c], José ACHOTEGUI-LOIZATE[a], Antoni TALARN-CAPARRÓS[a], Joan RIBAS-SABATE[d], Alexis ANDREU-GRACIA[e], Marina DÍAZ-MARSA[f], Miquel MONRÀS-ARNAU[g], Eduardo SERRANO-TRONCOSO[h], Janet TREASURE[i], and José GUTIÉRREZ-MALDONADO[a]

[a] *Department of Clinical Psychology and Psychobiology, Universitat de Barcelona, Barcelona, Spain*
[b] *Applied Technology for Neuro-Psychology Lab. Istituto Auxologico Italiano, Milan, Italy*
[c] *Department of Medicine and Surgery, University of Milano Bicocca, Milan, Italy*
[d] *Complejo Asistencial Benito Menni, Sant Boi de Llobregat, Spain*
[e] *Department of Psychiatry and Mental Health, Hospital General d'Igualada, Barcelona, Spain*
[f] *Unit of Eating Disorders, Hospital Clínico San Carlos de Madrid, Spain*
[g] *Department of Psychiatry, Hospital Clínic de Barcelona, Spain*
[h] *Department of Psychiatry, Hospital Sant Joan de Déu, Barcelona, Spain*
[i] *Department of Psychological Medicine, King's College London, UK*

Abstract. This study aimed to assess the ability of a virtual reality (VR)-based software to produce body anxiety responses in a non-clinical sample. 23 college students (5 male) were exposed to an immersive VR environment displayed with an HMD, where the illusion of ownership of a virtual body was induced by means of visuomotor synchronization. Each participant was exposed to three body sizes (from first-person perspective and from third-person perspective reflected in a mirror placed in the virtual environment): an avatar with the same body measurements as the participant, an avatar 20% larger than the participant, and another avatar 40% larger than the participant. BMI, drive for thinness (EDI 3-DT) and body dissatisfaction (EDI3-BD) were assessed before exposure, while body anxiety (PASTAS), fear of gaining weight (Visual analogue scale [VAS], from 0 to 100) and ownership illusion (VAS from 0 to 100) were assessed after exposure to each avatar. Students reported significantly higher levels of body anxiety and fear of gaining weight after owning a 40% larger virtual body than after owning a virtual body with their real measurements. When body dissatisfaction

* Corresponding Author: martaferrerg@ub.edu.

and drive for thinness was considered, only participants with higher scores in these scales showed a significant increment of body anxiety and fear of weight gain after exposure to the largest avatar. BMI had no effect on the results. This study provides evidence of the usefulness of virtual body ownership illusions to provoke weight and body related anxiety responses in individuals worried about their weight and body image and opens the door to its therapeutic use in patients with anorexia nervosa.

Keywords. virtual reality, body ownership illusion, visuomotor synchronization, body anxiety.

1.Introduction

Immersive virtual reality systems offer us the possibility to embody an avatar, which may have any feature we are interested in, within the virtual world. This fact has led to the emergence of several research lines that take advantage of embodiment techniques to assess emotional, cognitive and behavioural responses of individuals who own a virtual body with specific characteristics [1-3]. Embodiment techniques are based on the paradigm of rubber hand ownership illusion [4] and can be achieved by the synchronized stimulation of different sensory channels, for example, visuo-tactile (which is used in the rubber hand illusion), visuomotor and visuo-proprioceptive synchronization. Multisensory synchronization in virtual reality systems has been successfully used to provoke ownership illusion of a virtual body with a different size to that of the participant's real body size [5,6]. These studies showed that embodiment of a slimmer or a heavier virtual body induces both perceptual and cognitive changes in the way participants experience their own body, for example, diminishing or increasing body dissatisfaction. Given these findings, several authors have used such illusions to modulate perceived body size in patients with eating disorders (ED) and, thus, modify their disturbed body image [7,8].

Following this research line, we propose to take advantage of body ownership illusions in VR to expose patients with anorexia nervosa (AN) to their primary feared stimulus, i.e. the increase of weight. Patients with AN show high levels of anxiety and avoidance of food intake, associated with negative and rigid beliefs about the consequences of increasing weight. Avoidance behaviours prevent patients from realizing that normalization of weight does not lead to expected catastrophic consequences. All these features produce an extraordinary resistance to change, as one of the objectives of the intervention is precisely to increase weight. Therefore, the use of exposure therapy to one's own body, while progressively increasing weight, may be an effective method in order to reduce fear of gaining weight and, hence, to reduce rejection of food. As far as we know, there is only one case study in which imagery exposure was used with this aim, in a restrictive AN female patient who had shown resistance to the usual treatment [9]. Along five sessions, the patient had to imagine herself progressively increasing weight and facing the associated feared catastrophic consequences, such as criticism and social rejection. Authors reported that the patient increased weight during the intervention and maintained gain after one-month follow-up. Despite being a good option, imagery exposure has some important issues which may make the use of this procedure difficult in some patients, for example, difficulty in maintaining visualization long enough to reach the habituation or extinction of anxiety response, individual differences in the ability to visualize a situation, and risk of the most feared stimulus avoidance during visualization. Virtual reality, on the other hand, reduces the possibilities of avoidance behaviours and its efficacy is not conditioned by the

visualization abilities of the patients. Given that, VR exposure therapy could be an appropriate alternative.

The present study is part of a wider research, the final aim of which is to develop a VR-based application to reduce the fear that AN patients have of reaching a healthy weight and the consequent resistance to eating. A necessary first step in this research, was to assess the ability of VR-based software to induce body anxiety responses in participants. Specifically, we wanted to assess whether the embodiment in a fatter virtual body increases body anxiety and fear of gaining weight in college students, and to evaluate whether participants' BMI, body dissatisfaction, and drive for thinness, have an effect on results. It was expected that body anxiety and fear of gaining weight were higher after embodiment in a fatter virtual body than after embodiment in a virtual body of the participant's size. It was also expected that participants with higher BMI and higher levels of body dissatisfaction and drive for thinness showed more body anxiety and fear weight gain than participants with lower BMI, body dissatisfaction and drive for thinness.

2. Methods

23 college students (5 males and 18 female) participated in the study. Participants mean age was 24.91 (*SD*=4.78) and mean BMI was 22.18 (*SD*=4.41). After signing the informed consent, demographic data were collected and participants completed a test battery, which included the scales drive for thinness (EDI-DT) and body dissatisfaction (EDI-BD) of the Eating Disorders Inventory (EDI-2) [10]. Participants were also measured in order to calculate their BMI and to obtain the size of different body parts (shoulders, chest, waist, hips, thighs, and calves), needed to generate the avatar with the real measurements of the participant. Then, participants were exposed to an immersive VR environment displayed with an HMD (HTC-Vive), where the illusion of ownership of a virtual body was induced by means of visuomotor synchronization. The virtual situation consisted of a small room with light-coloured walls and a big mirror in front of an avatar with the same genre as the participant. Both assessment and exposure to VR were conducted individually. Visuomotor synchronization was performed from first-person perspective and from third-person perspective: first, participants were asked to look at the movement of their virtual arms from a first-person view, while moving their real arms at the same time (first perspective). After one minute, a mirror appeared on the wall in front the avatar and the participants were asked to look at the avatar reflected in the mirror while the virtual arms and the real arms of the participants moved synchronically for one minute (third perspective). All the movements were conducted following the instructions of the researcher.

Each participant was exposed to three body sizes: an avatar with the same body measurements as the participant, an avatar 20% larger than the participant, and another avatar 40% larger than the participant. After exposure to the avatar with the real body measurements and the avatar 40% larger, the participants left the VR system to answer several questionnaires, which included the Weight Subscale of the Physical Appearance State Anxiety Scale (PASTAS-W) [11] and two visual analogue scales (VAS, from 0 to 100) to assess fear of gaining weight (VAS-FGW) and ownership illusion (VAS-OI). On the other hand, after exposure to the avatar 20% larger, the participants did not leave the VR system but, instead, the researcher asked them to rate from 0 to 100 the fear of gaining weight and the feeling of ownership illusion while they remained exposed to the

black screen. Before finishing the experiment, participants were exposed again to the avatar with their real measurements and possible worry or discomfort related with body image was attended by the researcher.

2.1 Statistical Analyses

Two repeated measures analysis were conducted in order to assess the effect of variable size (real size, 20% larger size, and 40% larger size) on body anxiety (PASTAS-W) and fear of gaining weight (VAS-FGW) reported by participants during exposure to the virtual bodies. It is important to notice that, when analysing body anxiety, only two sizes were considered, as PASTAS-W was only administered after owning the real size virtual body and the 40% larger virtual body. In contrast, when analysing fear of gaining weight, all sizes (real size, 20% larger size, and 40% larger size) were considered, as VAS-FGW was administered three times (see procedure section). Several mixed between-within analyses of variance were also conducted in order to assess whether BMI, drive for thinness and body dissatisfaction influenced on body anxiety and fear of gaining weight experienced during embodiment in the different virtual bodies. To do these analyses, the sample was divided in two equal groups according BMI (high vs. low, percentile 50 = 21), EDI-BD (high vs. low, percentile 50 = 1), and EDI-DT (high vs. low, percentile 50 = 0). In those analyses where sphericity assumption were violated (Mauchly´s test $p<.05$), degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε).

3. Results

The strength of ownership illusion was high in all conditions: real size virtual body (M=66.09, SD= 3.64), 20% larger virtual body (M=61.74, SD= 4.01) and 40% larger virtual body (M=53.78, SD= 5.92).

Repeated measures analyses revealed a significant effect of virtual body size on body anxiety and fear of gaining weight (Table 2). Participants reported significant higher levels of body anxiety after owning the 40% larger virtual body than after owning the real size virtual body (Table 1). Likewise, participants reported more fear of weight gain after owning the 40% larger virtual body than after owning the 20% larger virtual body ($F(1,22)=18.104$, $p<.001$, $\eta^2=.451$) or the real size virtual body ($F(1,22)=18.383$ $p<.001$, $\eta^2=.455$). All the analyses showed very large effects.

Table 1. Mean body anxiety (PASTAS-W) and fear of gaining weight (VAS-FGW) through embodiment to a real size virtual body, a 20% larger virtual body and a 40% larger virtual in participants with low (*n*=12) and high (*n*=11) BMI, low (*n*=13) and high (*n*=10) drive for thinness and low (*n*=12) and high (*n*=11) body dissatisfaction.

	Real size virtual body		20% larger virtual body		40% larger virtual body	
PASTAS-W	*M*(*SD*)		*M*(*SD*)		*M*(*SD*)	
	Low	high	Low	High	Low	High
BMI	1.42(1.50)	4.73(6.18)	-	-	3.33(4.77)	7.91(5.13
EDI-DT	1.25(1.36)	5.30(6.27)	-	-	1.85(1.82)	10.30(8.08)
EDI-BD	1.25(1.42)	4.91(6.09)	-	-	1.67(1.61)	9.73(7.94)
Total (*N*=23)	3(4.62)		-	-	5.52(6.85)	
VAS-FGW						
BMI	14.33(22.94)	5.45(12.93)	10.25(18.94)	7.27(14.21)	17.75(20.29)	10(17.89)
EDI-DT	10.77(22.53)	9.20(14.17)	8.46(18.64)	9.30(14.31)	9.23(18.01)	20.30(19.69)
EDI-BD	11.67(23.29)	8.36(13.73)	9.17(19.29)	8.45(13.87)	10(18.59)	18.45(19.65)
Total (*N*=23)	10.87(19.52)		9.57(17.70)		17.17(22.40)	

Note: PASTAS-W (Body anxiety questionnaire), VAS-FGW (Fear of gaining weight), BMI (Body mass index), BD (Body dissatisfaction scale), DT (Drive for thinness scale), *M* (Mean), *SD* (Standard deviation).

Mixed within-between analyses of variance were also conducted in order to assess differences in body anxiety and fear of weight gain according BMI, body dissatisfaction, and drive for thinness were also assessed. As shown in table 2, the interaction between the virtual body size and the BMI of participants was not significant (small effect size). Participants with low (≤21) and high BMI (>21) showed similar levels of body anxiety and fear of gaining weight in all conditions. In contrast, interaction between drive for thinness and virtual body size and between body dissatisfaction and virtual body size were significant when assessing body anxiety. Thus, participants with low drive for thinness and body dissatisfaction showed similar levels of body anxiety in all the conditions, while participants with high drive for thinness and body dissatisfaction showed significantly higher levels of body anxiety after owning the 40% larger virtual body than after owning the real size virtual body. Likewise, interaction between virtual body size and drive for thinness was significant when assessing fear of weight gain. Whereas participants with low drive for thinness showed similar fear of gaining weight in all conditions, participants with high scores of drive for thinness reported significantly higher levels of fear of weight gain after owning the 40% larger virtual body than after owning the 20% larger virtual body or the real size virtual body. Finally, although interaction did not reach significance (p=.06), the same tendency was observed when assessing the effect of body dissatisfaction scores. Participants with high body dissatisfaction scores, but not participants with low scores, reported more fear of gaining weight after owning the 40% larger virtual body than in the other conditions. Again, all these analyses showed large or very large effects.

Table 2. Main effects and interactions of repeated measures analyses of variance and mixed analyses of variance for both body anxiety (PASTAS-W) and fear of gaining weight (VAS-FGW)

	PASTAS-W			VAS-FGW		
	F	*P*	η^2	*F*	*p*	η^2
Size	7.187	.014	.246	16.952	<.001	.435
Size x BMI	.440	.514	.021	.788	.411	.036
Size x DT	11.038	.017	.243	4.103	.039	.163
Size x BD	6.938	.016	.248	3.437	.061	.141

Note: PASTAS-W (Body anxiety questionnaire), VAS-FGW (Fear of gaining weight), BMI (Body mass index), BD (Body dissatisfaction scale), DT (Drive for thinness scale).

4. Discussion and conclusions

The main objective of this study was to assess whether owning a fatter virtual body increased body anxiety and fear of gaining weight in college students. As expected, students reported higher levels of body anxiety and fear of weight gain after owning a fatter virtual body than after being exposed to an avatar with their real measurements. According to previous research [5-7], virtual body ownership illusion is able to produce changes in one's own body image. Most importantly, when body dissatisfaction and drive for thinness were considered, results made it evident that embodiment in a fatter virtual body only had a significant effect in those students with higher levels of body dissatisfaction and drive for thinness, that is, those who experience more food, weight and body image related concerns. It is therefore expected, that anxiety and fear responses after owning a larger virtual body would be even higher in AN patients. Likewise, although differences didn't reach significance, participants with higher BMI reported higher levels of body anxiety and fear of gaining weight after owning the largest virtual body. It must be noticed that only five participants were overweight (only one obese) in our sample. Possibly, in a wider sample, including more overweight participants, differences related with BMI would reach significance.

Despite limitations, such as the small sample size and the lack of a control condition (asynchronous visuomotor stimulation), this study provides evidence of the usefulness of virtual body ownership illusions to provoke weight and body related anxiety responses in individuals worried about their weight and body image. This finding constitutes a step forward towards the development of VR-based tools for body exposure therapy to reduce weight gain anxiety in AN patients and the consequent resistance to change that characterizes these patients. Besides exposing patients to an avatar representing their own body image and whose size increases progressively (according a pre-established hierarchy), another critical advantage of virtual reality is that it allows us to contextualize exposure in different virtual environments simulating real-life situations (home, restaurant, supermarket, etc.) where weight gain may have catastrophic consequences according patient's negative beliefs (social rejection, criticism, etc.) and, hence, makes generalization of changes easier beyond the therapist's office.

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