Embodiment in different size virtual bodies produces changes in women's body image distortion and dissatisfaction

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Introduction: Body image disturbance is considered a pervasive issue among women and is a core feature of eating disorders. Previous research provides evidence of the ability of body ownership illusions in virtual reality to produce changes in one's own body representation, especially in body size estimation. However, less information is available about changes in subjective body attitudes. This study assesses whether owning a female virtual avatar with different body sizes produces changes in body image distortion and body image dissatisfaction in women. **Method:** Forty female college students were exposed to an immersive virtual environment, in which they were sequentially embodied in three avatars using synchronous visuo-tactile stimulation. The first and third avatar had the same body size as the participant, but the second one had a larger body size. In the larger avatar condition, the group was divided into two: 20 participants owned a virtual body 20% larger and the other twenty a virtual body 40% larger. Body image distortion and body image dissatisfaction were assessed before and after embodiment in each of the three avatars using a silhouette test. **Results:** Mixed between-within analyses of variance showed a statistically significant effect of the variable Time (four assessment points) on body image distortion (F (3, 38) =2.825, p=.042, η^2 = 0.069) and body image dissatisfaction (F (3, 38) =6.933, p<.001, η^2 = 0.154). The effect of the variable Group (20% increase versus 40% increase in the larger body size avatar) and the interaction between time and group were not statistically significant. Overall, participants reported a reduction in the body image overestimation after owning the same-size avatar for the second time (M=8.88, SD=12.48) than at the other assessment points (at pre-test: M=13.00, SD=17.09; after owning the first same-size virtual body: M=13.75, SD=11.14; and the larger size avatar: M=14.50, SD=15.18). As regards body image dissatisfaction, the highest levels were recorded at pre-test (M=16.38, SD=18.54) and after owning the larger size avatar (M=15.50, SD=19.57) and lowest levels after owning the same-size avatar for the second time (M=6.88, SD=13.85). More interestingly, the reduction in body dissatisfaction after owning the same-size avatar for the second time compared with pre-test was statistically significant (F (1, 38) =18.098, p<.001, η^2 = 0.323). **Conclusion:** This study extends the evidence available about the ability of full virtual body ownership illusions to modify the mental representation of one's own body. Owning a virtual body with different body sizes produces changes not only in size overestimation but also in body dissatisfaction; and, most importantly, in-

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ducing the ownership illusion of a larger-size virtual body reduces body dissatisfaction when subjects return to the same-size avatar, probably due to a comparison effect.

Keywords: virtual reality, body ownership illusion, visuo-tactile synchronization, body image distortion, body image dissatisfaction

Introduction

Body image disturbance (BID), including both body image distortion and body image dissatisfaction, is considered a pervasive issue among women [1, 2] and is a core feature of eating disorders [3] (ED). Therefore, addressing BID is considered a critical aspect for the prevention and treatment of ED [4]. Previous research suggests that the mental representation of body image can be updated, based on incoming multisensory information [5, 6]. Indeed, several studies have used body ownership illusions of a virtual body to manipulate the perception of one's own body image [7-9]. Full body ownership illusion is defined as the subjective experience in which individuals feel an artificial body to be their own body [10] and is produced when different types of information (visual, proprioceptive, haptic, etc.) are combined into a multisensory representation [11].

Several studies have shown that full body ownership illusion-based interventions produce changes in the perception of one's own body size and shape [8, 9, 11, 12]. Preston and Ehrsson [8], for instance, induced full body ownership illusion of a mannequin in a group of individuals. This mannequin could be slimmer or larger than the individual's body size. They found a significant reduction in perceived body size and an increase in body satisfaction after owning the slimmer mannequin body. Similarly, Serino et al. [11] found a decrease in participants' perceived body size after they were embodied in a skinny belly avatar. Similar results have been found in clinical samples. Keizer and colleagues [13] found that owning a healthy-size virtual body significantly decreased perceived body size in patients with anorexia nervosa (AN) as well as in non-clinical participants, and that this perceived body size reduction persisted two hours later.

The main objective of this study was to assess the ability of the virtual body ownership illusion to produce changes in both perceptual and attitudinal aspects of body image in a non-clinical sample of women. Participants were expected to show higher levels of body image distortion and dissatisfaction after owning a virtual body that was larger than their own body than after owning a virtual body with the same body size. The distortion and dissatisfaction were also expected to be greater with larger virtual body sizes.

1. Methods

1.1. Participants

Forty female college students with an age range from 18 to 42 (M=22.55, SD= 4.02) and a body image index (BMI) range from 16.6 to 28.49 (M=21.65, SD=0.40) partici-

pated in the study. According to the World Health Organization [14], 33 participants (82.5%) had healthy weight ($18.5 \leq BMI \leq 25$), three (7.5%) were underweight and four (10%) were overweight. Self-reported current ED diagnosis was considered an exclusion criterion.

1.2. Procedure

The current study was approved by the research Ethics Committee of the University of Barcelona. After signing the informed consent document, participants provided demographic data and completed the Figure Drawing Scales for Body Image Assessment (BIAS-BD) [2]. The BIAS-BD is a silhouette test that assesses body image dissatisfaction (BIAS-O) and body image distortion (BIAS-X). BIAS-O is assessed by comparing the discrepancy between the perceived body size and the desired body size, and BIAS-X by the discrepancy between the perceived body size and the real body size. Participants were also measured and weighed to calculate their BMI. After completing the test battery, a whole body photograph of the participant was taken and then used to create an avatar with a silhouette similar to that of the participant. Then, participants were sequentially embodied in three avatars using synchronous visuo-tactile stimulation. The stimulation consisted in a series of touches to the participants' arms (during 15 seconds each one), abdomen (during 30 seconds), and legs (during 15 seconds each one) by the experimenter using one of the HTC-VIVE controllers, while the participants looked at themselves (i.e., first-person perspective) in the virtual environment being touched by the HTC-VIVE controller (during 90 seconds) and, then, to the avatar reflected in a mirror in front of them (i.e., third-person perspective) during 90 seconds. The first and third avatar had the same body size as the participant, but the second avatar had a larger body size. In the larger avatar condition, the group was divided into two: 20 participants owned a virtual body 20% larger than themselves, and the other twenty a virtual body 40% larger. Body image distortion and body image dissatisfaction were assessed again after embodiment in each of the three avatars using the BIAS-BD.

1.3. Virtual setting

The virtual environment was a room without any furniture but with a large mirror on the front wall, where the participants could see their virtual body. The environment was displayed using a head mounted HTC-VIVE display connected to a computer with enough graphic power to move virtual environments. The avatars were developed using Blender 2.78v, and Unity 3D 5.5.v was used to integrate all the elements within the virtual environment.

1.4. Statistical Analyses

Mixed between-within analyses of variance were conducted, introducing the within participants' variable Time (four assessment points: at pre-test, after owning the real-size virtual body, after owning the larger-size virtual body, and after owning the real-size virtual body again) and the between participants' variable Group (20% larger-size virtual body versus 40% larger-size virtual body). Post hoc tests comparing the four assessment points were also conducted. Normality (Kolmogorov-Smirnov's test $p>.05$), sphericity (Mauchly's test $p>.05$) and homogeneity (Levene's test $p>.05$) assumptions were checked.

2. Results

Mixed between-within analyses of variance showed a statistically significant main effect of the variable Time (four assessment points) on body image distortion and body image dissatisfaction (Table 1), with low and medium effect sizes respectively. In contrast, the main effect of the variable Group (20% increase versus 40% increase in the larger-size virtual body) and the interaction between Time and Group were not statistically significant.

Table 1. Main effects and interaction between the variables Time and Group in body image distortion and body image dissatisfaction.

	BIAS-X			BIAS-O		
	F (1,38)	*p*	η^2	*F* (1,38)	*p*	η^2
Time	**2.825**	**.042**	**.069**	**6.933**	**<.001**	**.154**
Group	.816	.372	.021	1.462	.234	.037
Time x Group	.798	.377	.021	.369	.547	.010

Note: BIAS-X (Body image distortion), BIAS-O (Body image dissatisfaction).

As table 2 shows, participants as a whole reported a reduction in body image overestimation after owning the real-size virtual body for the second time as compared with the other assessment points (at pre-test, after owning the real-size virtual body for the first time, and after owning the larger-size avatar). On the other hand, although overestimation after owning the larger-size virtual body was slightly greater in 40% size increase group than in the 20% size increase group (Table 2), the differences did not reach statistical significance ($t_{(38)}$=-1.369, p>.05). As regards body image dissatisfaction, the highest levels were recorded at pre-test and after owning the larger-size virtual body, while the lowest were reported after owning the same-size virtual body for the second time. Again, differences between groups after owning the larger-size virtual body did not reach significance ($t_{(38)}$=-1.135, p>.05).

Table 2. Mean body image distortion and body image dissatisfaction at pre-test and through embodiment to the real-size virtual body for the first time, the larger-size virtual body (20% or 40% larger) and the real-size virtual body for the second time in group 1 (n=20, participants who embodied the 20% larger-size virtual body), group 2 (n=20, participants who embodied the 40% larger-size virtual body), and the whole sample (N=40).

	Pre-test		Real-size virtual body 1		Larger-size virtual body		Real-size virtual body 2	
	Group 1 *M* (*SD*)	Group 2 *M* (*SD*)	Group 1 *M* (*SD*)	Group 2 *M* (*SD*)	Group 1 *M* (*SD*)	Group 2 *M* (*SD*)	Group 1 *M* (*SD*)	Group 2 *M* (*SD*)
BIAS-X	11.50 (16.63)	14.50 (17.84)	13.75 (10.75)	13.75 (11.80)	11.25 (15.80)	17.75 (14.19)	7.00 (11.74)	10.75 (13.21)
Total N=40	13.00 (17.09)		13.75 (11.14)		14.50 (15.18)		8.88 (12.48)	
BIAS-O	12.50 (18.39)	20.25 (18.32)	10.25 (15.08)	14.50 (18.98)	12.00 (21.36)	19.00 (17.44)	5.00 (16.22)	8.75 (11.11)
Total N=40	16.38 (18.54)		12.37 (17.06)		15.50 (19.57)		6.88 (13.85)	

Note: BIAS-X (Body image distortion), BIAS-O (Body image dissatisfaction), *M* (Mean), *SD* (Standard deviation).

Post hoc within-subject contrast tests for the variable time (Table 3) showed significantly lower levels of body image distortion and body image dissatisfaction after owning the real-size virtual body for the second time than after owning the larger-size vir-

tual body and after owning the real-size virtual body for the first time. Most importantly, the reduction in body dissatisfaction after owning the same-size avatar for the second time compared with pre-test levels was also statistically significant, with a large effect size (Table 3).

Table 3. Within-subject contrast tests for the variable Time.

Time	BIAS-X			BIAS-O		
	F (1,38)	*p*	η^2	*F* (1,38)	*p*	η^2
Pre-test vs real-size avatar 1	.117	.735	.003	2.633	.113	.435
Pre-test vs larger-size avatar	.612	.439	.016	.163	.689	.004
Pre-test vs real-size avatar 2	3.03	.09	.014	**18.098**	**<.001**	**.323**
Real-size avatar 1 vs larger-size avatar	.136	.715	.004	2.031	.162	.051
Real-size avatar 1 vs real-size avatar 2	**8.057**	**.007**	**.175**	**5.548**	**.024**	**.127**
Larger-size avatar vs real-size avatar 2	**5.636**	**.023**	**.129**	**12.572**	**.001**	**.249**

Note: BIAS-X (Body image distortion), BIAS-O (Body image dissatisfaction).

3. Discussion and conclusions

The main aim of this study was to assess whether embodiment in different size virtual bodies produced changes in the level of body image distortion and body image dissatisfaction in a non-clinical sample of women. As expected, participants showed higher levels of body image distortion and body image dissatisfaction after owning the larger-size virtual body than after owning the real-size one for the second time. These results are in line with previous research showing that the mental representation of body image is malleable [8,9,13] and may change according to emotional and situational contexts [15].

On the other hand, no significant differences were found between groups with regard to owning the real-size avatar for the first time and owning the larger-size one. Two related factors may help to explain these results. First, most participants (90%) had a healthy weight or were underweight. Consequently, it may be that even an increase of 40% did not lead to a substantially overweight figure. Second, as participants were from a non-clinical sample, a weight increase of 20 or 40% probably did not induce such an intense response as expected.

However, the most interesting finding in this study is the notable reduction in body image distortion and dissatisfaction after owning the real-size avatar for the second time compared with the results after owning the real-size avatar for the first time and, in the case of body dissatisfaction, at pre-test. According to Keizer and colleagues [13], the mental representation of the body depends on input from multiple sensory modalities and, therefore, full body ownership illusions could be useful for reducing the misestimation of body size in ED patients. These authors found that body image distortion fell in both anorexia patients and healthy controls after owning a healthy-size virtual body [13]. The fact that, in our study, the reduction was higher after owning the second real-size avatar than after owning the first one is probably due to a comparison effect, since prior to owning the second real-size avatar they had owned the larger-size avatar.

This study has several limitations that should be also considered. First, the sample was recruited among female college students and, consequently, results cannot be generalized to other populations. Second, no structured interview or screening test was

administered to assess the presence of an ED. Finally, body mass index was not considered in this study. Future research should take into account possible differences between overweight, normal-weight and underweight participants, as well as gender differences. Despite these limitations, however, the study adds to the currently available evidence on the ability of full virtual body ownership illusions to modify the mental representation of one's own body, and provides added support for its use in body image disturbance treatment in eating and weight-related disorders.

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References

[1] S. K. Bearman, K. Presnell, E. Martinez, E. Stice, The skinny on body dissatisfaction: A longitudinal study of adolescent girls and boys. *Journal of Youth and Adolescence* **35** (2006), 229-241.

[2] R.M. Gardner, L.M. Jappe, L. Gardner, Development and validation of a new figural drawing scale for body image assessment: the BIAS-BD, *Journal of Clinical Psychology* **65**(1) (2009), 113-122.

[3] R.M. Gardner, D.L. Brown, Body size estimation in anorexia nervosa: a brief review of findings from 2003 through 2013. *Psychiatry Research* **219**(3) (2014), 407-410.

[4] C. Farrell, R. Shafran, M. Lee. Empirically evaluated treatments for body image disturbance: A review. *European Eating Disorders Review* **14**(5) (2006), 289-300.

[5] D. Banakou, R. Groten, M. Slater, Illusory ownership of a virtual child body causes overestimation of object sizes and implicit attitude changes, *Proceedings of the National Academy of Sciences* **110**(31) (2013), 12846-12851.

[6] C. Preston, R. Newport, How long is your arm? Using multisensory illusions to modify body image from the third person perspective, *Perception* **41** (2012), 247-249.

[7] A. Keizer, A. van Elburg, R. Helms, C. Dijkerman, A virtual reality full body illusion improves body image disturbance in anorexia nervosa, *PLoS ONE* **11** (2016), e0163921.

[8] C. Preston, H.H. Ehrsson, Illusory changes in body size modulate body satisfaction in a way that is related to non-clinical eating disorder psychopathology, *PLoS ONE* **9** (2014), e85773.

[9] I.V. Piryankova, H.Y. Wong, S.A. Linkenauger, C. Stinson, M.R. Longo, H.H. Bülthoff, B.J. Mohler, Owning an overweight or underweight body: distinguishing the physical, experienced and virtual body, *PLoS ONE* **9** (2014), e103428.

[10] A. Maselli, M. Slater, The building blocks of the full body ownership illusion. *Frontiers in human neuroscience* **7** (2013), doi.org/10.3389/fnhum.2013.00083.

[11] S. Serino, E. Pedroli, A. Keizer, S. Triberti, A. Dakanalis, F. Pallavicini, A. Chirico, G. Riva, Virtual reality body swapping: a tool for modifying the allocentric memory of the body, *Cyberpsychology, Behavior, and Social Networking* **19** (2016), 127-133.

[12] C. Preston, B.J. Kuper-Smith, H.H. Ehrsson, Owning the body in the mirror: the effect of visual perspective and mirror view on the full-body illusion, *Scientific reports* **5** (2015), 18345.

[13] A. Keizer, A. van Elburg, R. Helms, H.C. Dijkerman, A virtual reality full body illusion improves body image disturbance in anorexia nervosa. *PloS one* **11**(10) (2016), e0163921.

[14] World Health Organization (WHO), Body mass index, retrieved from http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi, (2017, Mars 12)

[15] M. Ferrer-Garcia, J. Gutiérrez-Maldonado, A. Caqueo-Urízar, E. Moreno. Body Image in Eating Disorders: The Influence of Exposure to Virtual-Reality Environments, *Cyberpsychology, Behavior, and Social Networking* **13**(5) (2010), 521-531.