Heart rate variability as a measure of body anxiety: body image exposure using VR embodiment.

1.INTRODUCTION

Eating disorders (ED) play a significant role in health care worldwide. Among specific types of eating disorders, the highest prevalence was found for binge eating disorders (BED), followed by bulimia nervosa (BN), and anorexia nervosa (AN) (Qian et al., 2013).

Eating disorder literature supports the use of cognitive behavioral therapy or interpersonal psychotherapy for adolescents and adolescent family counselling (Lock, 2015; Fairburn et al., 2015; Kass, Kolko, & Wilfley, 2013). Nonetheless, there are a number of patients who may not improve through therapy (Wilson, Grilo, & Vitousek, 2007).

The study of heart rate variability (HRV) in patients with ED provided clinically relevant knowledge of the quality and role of various physiological processes for heart rate regulation (Shaffer & Ginsberg, 2017). Is for these reasons that the interest in this measure has increased in the late years.

The main aim of the present study was to determine if the induction of the full body illusion (FBI) of a virtual body produced changes in body-related anxiety, body image disturbances and HRV of non-clinical participants. Participants owned two different virtual bodies (VBs): one with the same BMI as their own and another with an increment of 7 points in their BMI.

2.METHODS

2.1 Participants

The sample consisted of 40 female master students from the University of Barcelona (Mage=25, SD=4.673). We used only female participants in our experiment mainly because there is a sex difference in the way people perceive the size of their physical body (Grogan, 2007).

All students participated in this study after providing written informed consent. The exclusion criteria were a body mass index (BMI) of less than 17 (moderate thinness) or more than 30 (obesity) or a self-reported current sever mental disorder diagnosis (e.g., schizophrenia or bipolar disorder).

2.2 Measures

2.2.1 Assessment of body image

- *Eating Disorder Inventory-3 (EDI-3):* The EDI–3 is a self-report measure of psychological traits and symptoms relevant to the development and maintenance of anorexia nervosa (AN), bulimia nervosa (BN), and eating disorder not otherwise specified (EDNOS). In this study we assessed one scale: Body Dissatisfaction (BD) (Cumella, 2006).
- *Physical Appearance State and Trait Anxiety Scale (PASTAS):* This body anxiety questionnaire consists of two independent self-reporting scales that assess weight-related and non-weight-

related anxiety. We used the weight scale (W) in this analysis. The PASTAS-W correlated highly with available measures of body dissatisfaction, appearance evaluation, and eating disturbance (Reed, Thompson, Brannick & Sacco (1991).

2.2.2 Assessment of HRV

- *Stress Index*: The Baevsky's stress index is a rather widely used index of cardiovascular system stress and is strongly linked to sympathetic nervous activity.
  The stress index shows the rhythm stabilisations and disorder reductions in the cardio-interval length, which are calculated from the histogram of the heart rhythm distribution curve (Mayrhofer, Quendler, Prinz & Nimmerichter, 2017).
- *Sympathetic Nervous System Index (SNS)*: Increased HR is associated with increased cardiac sympathetic activation. It is calculated as a function of mean HR (bpm), Baevsky stress index and SD2 that refers to the standard deviation of the orthogonal intervals of the points RRi, RRi+a to the transverse diameter of the ellipse (%) (Goto et al., 2007).

2.3 Instruments

HRV Recording Methods

HR measurements were performed using a Polar H10 monitor set to R-R interval mode (Polar Electro, Kempele, Finland) together with a chest-built recording strip. The Polar H10 chest strap collected and processed HRV measurements by detecting the electrical signals of the heart (Speer et al. 2020).

2.4 Procedure

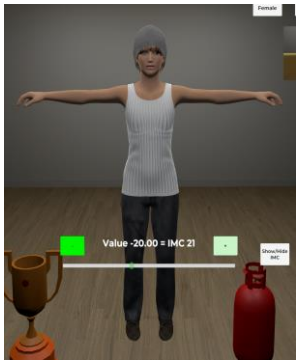
PRE-ASSESSMNET	**REAL-SIZE VB**	**LARGER-SIZE VB**
Whole body photography HRV measures PASTAS Body anxiety State EDI-BD Weight and height measurements	PASTAS HRV measures	PASTAS HRV measures
BASE LINE HRV: relaxation virtual environment	**VISUO-MOTOR STIMULATION PROCEDURE (45'')**	
2 GROUPS High BD Low BD		

Figure 1. Experimental design scheme. Between-subjects group condition (High versus Low BD), within-subjects assessment condition (pre-assessment, real-size and larger-size virtual bodies), and dependent variables reported.

3.RESULTS

3.1 Descriptive results

Participants were on average 25 years old (SD=4.673) and had a normal weight BMI (M=22.26, SD=3.322). The mean hours of physical activity were 2.45 hours/week (SD=2.579). No participant was known to be taking any medication or have any cardiovascular problems or any other current medical disease of interest that may have influenced the procedures carried out.

Two-way mixed ANOVA were conducted. Means and standard deviations of all dependent variables were specified for each experimental condition at the different assessment times.

3.2 Statistical analysis

Stress Index differ significantly between the two groups ($p<.05$) in all the conditions (see Figure 2b). Stress Index scores were significantly higher in the high EDI-BD than in the low-EDI-BD group in all the three conditions (baseline $F(1,38)=4.700$, $p=.037$, partial $\eta^2 = .110$; real size-VB $F(1,38)=6.581$, $p=.014$, partial $\eta^2 = .148$; large-size VB $F(1,38)=5.979$, $p=.019$, partial $\eta^2 = .136$).

Table 2. Mixed-between-within subjects analysis of variance comparing groups (Group 1- High EDI body dissatisfaction versus Group 2- Low EDI body dissatisfaction) with the different test conditions.

	Time x Group			**Time of Assessment**			**Group Effect**		
	F	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2
PASTAS	0.178	0.731	0.001	19.400	<0.000*	0.144	16.887	<0.000*	.229
Stress Index	3.207	0.054	0.013	4.676	0.017*	0.019	6.573	.014*	.126
SNS	2.830	0.079	0.011	28.486	<0.000*	0.093	4.395	.044*	.090

Regarding the PASTAS questionnaire, there was a main effect of group [$F(1,38)=16.887$, $p=.000$, $\eta^2 =.229$], wherein women with high BD (M= 9.629, SD= 6.718) had higher scores of anxiety levels (PASTAS) than women with low BD (M= 2.954, SD= 2.578). Assessment time also had a significant impact on PASTAS [$F(1,38)=19.400$, $p=.000$, $\eta^2 =.144$].

As can be seen in Table 3 Post hoc comparisons using the Tukey HSD test indicated that the mean score for SNS in the pre-assessment condition was lower than in the other two conditions. Moreover, mean scores for PASTAS were higher in the Increase BMI condition than in the others.

Table 3. Post-hoc analyses (pairwise comparison) at the different assessment times (pre-assessment, real size and increase in BMI).

	ASSESSMENT TIME CONDITION					
	Pre-Assessment vs Real-Size		Pre-Assessment vs Increase BMI		Real-Size vs Increase BMI	
	MD	SE	MD	SE	MD	SE
PASTAS	.5	.855	4.9*	.855	4.4*	.855
SNS	1.256*	.197	1.154*	.197	-.103	.197

*Significant *p* values <.05

4. DISCUSSION

In studying the impact of owning a large virtual body in participants with BD, we hope to determine whether women with BD would experiment high rates of body anxiety and low HRV, in order to gain further understanding of the specific mechanisms of body image.

As predicted, all participants, regardless of group, showed higher levels of body anxiety (PASTAS) after owning a larger virtual body (VB) than after owning a real-size VB, and scores were higher in the High BD group than in the Low BD group. Like in other studies, these results support the idea that internal and external stimuli could affect body image, such as owning a large VB (Ferrer-García, M. & Gutiérrez-Maldonado, 2012).

Regarding body anxiety levels, these results are in line with those of a previous study by our group, in which healthy college students undergoing visuomotor procedure reported higher levels of body anxiety and fear of weight gain after owning a larger-size VB than after owning their real-size VB (Porras-Garcia et al., 2019). Furthermore, body anxiety levels did not differ significantly after owning a virtual avatar with participants' real measurements (real-size VB) compared with the pre-assessment. This indicates all participants produced, interpreted, and experienced the real-size VB as their own body, independent of the extent of BD, even without being conscious of it (Porras-Garcia et al., 2019).

Another relevant point of this study was to validate HRV measures as an instrument for measuring body image alterations. A marginal interaction was found between group and time of assessment in Stress Index. It must be noticed that only 16 participants had high BD in our sample. Possibly, in a wider sample, including more participants with high BD, interaction between group and time condition would reach significance.

Peschel et al. (2016) found differences in resting state vagal activity comparing individuals with BN and healthy controls. In a highly comparable way, people with high BD show high Stress Index and SNS than people with low BD in a resting state meaning that resting state vagal activity is increased in individuals with high BD compared to controls.

Another important point to address is the use of the median to divide the sample in high and low body dissatisfaction. The median value does not take into account the precise value of each observation and hence does not use all information available in the data. Mean is generally considered the best measure of central tendency and the most frequently used one (Manikandan, 2011). However, in this case we decided to use the median to avoid a few extreme scores that we had in the distribution.

Facing limitations such a limited sample size, this research provides evidence of the efficacy of virtual body ownership illusions to provoke body related anxiety responses in individuals with body dissatisfaction. Moreover, these insights may contribute to an improved understanding of eating disorders, particularly body distortion mechanisms as well as the apparently complex interactions between its HRV measures and physiological functions.

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