ORIGINAL ARTICLES

Virtual Reality in the Assessment and Treatment of Weight-Related Disorders

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Abstract

Virtual Reality (VR) has, for the past two decades, proven to be a useful adjunctive tool for both assessment and treatment of patients with eating disorders and obesity. VR allows an individual to enter scenarios that simulate real-life situations and to encounter food cues known to trigger his/her disordered eating behavior. As well, VR enables three-dimensional figures of the patient's body to be presented, helping him/her to reach an awareness of body image distortion and then providing the opportunity to confront and correct distortions, resulting in a more realistic body image and a decrease in body image dissatisfaction. In this paper, we describe seminal studies in this research area.

Virtual Reality in the Assessment of Weight-Related Disorders

RIVA CONDUCTED the pioneering studies on the application of virtual reality (VR) for the assessment and treatment of body image disturbances[1] in the context of the European VREPAR Project (Virtual Reality Environments for the Psycho-neuro-physiological Assessment and Rehabilitation Project). The main purposes of this project were to study certain mental disorders and to develop new therapeutic techniques for their treatment and rehabilitation. Riva developed a software package for the assessment of body image disturbances, known as the Body Image Virtual Reality Scale (BIVRS).[2–4] The BIVRS is a nonimmersive, three-dimensional (3D) graphical interface through which the participant can choose between nine figures, male and female, ranging from underweight to overweight. Participants must choose those figures that best fit their self-perceived and their desired body size. Discrepancy between the two measures is an indicator of body image dissatisfaction. The BIVRS improves upon traditional assessment methods based on silhouettes by adding the third dimension to the figures presented to the user; consequently, the figures are more realistic and this makes it easier for participants to identify with them.

Perpiñá et al., in Spain, developed another application for the assessment of body image disturbances.[5] The assessment software consists of a 3D human figure whose body parts can be enlarged or made smaller using sliders. The main ad-vantage of this application is that (as it is immersive) the user can manipulate the figure while both are in the same virtual environment, which implies that the figure presented to the user has a similar size. This method also assesses several dimensions or indexes of body image (e.g., the perceived body, the desired body, and the healthy body) and body weight (actual weight, subjective weight, healthy weight, and desired weight), all in different contexts.

Virtual Reality in the Treatment of Weight-Related Disorders

Riva and colleagues[1,3,4] were also pioneering in the development of a VR application for the treatment of body image disturbances: the Virtual Environment for Body Image Modification (VEBIM).

The main problem facing therapists when treating body image disturbances is perhaps the lack of awareness that patients show about the real state of their bodies. Riva starts from the premise that body image distortion is a cognitive bias and, as such, it is barely accessible to consciousness. It has been shown that common distortions and desynchronizations produced in VR systems can alter people's lived experience. Discrepancies between the signals arriving from the user's proprioceptive system and the external signals from the virtual environment alter body perceptions and may have undesirable consequences such as discomfort or simulator sickness. However, these same effects can be used for therapeutic purposes as they involve a greater

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awareness of the associated sensorimotor and perceptual processes. When a particular event or stimulus is discordant with body schemata information, such as occurs during the virtual experience, this information becomes conscious.[6] This, in turn, facilitates the process of changing a disturbed body image since, according to Riva, body schema changes involve body image changes as the objective of the self is to integrate and maintain the consistency of different body representations. Furthermore, VR experience may enhance cognitive-behavioral techniques: using VR, the therapist can actually demonstrate that what looks like a perception does not really exist. This gets across the idea that a person can have a false perception. Once this has been understood, individual maladaptive assumptions can then be challenged more easily.[7]

Riva[2,4,8,9] conducted some preliminary studies with a nonclinical population to assess the VEBIM. Given their positive results, Riva et al.[7,10,11] then administered these virtual environments to a 22-year-old woman with anorexia nervosa (purging type).

After eight treatment sessions, the participant had increased awareness of her own body. She had not yet looked in the mirror, but this was proposed as the next target. Altering her body representation allowed this patient to reduce significantly her level of body dissatisfaction. There was also a reduction in the avoidance behaviors and grooming habits associated with a negative body image. By the end of treatment, she showed a greater motivation for change and expressed her desire to continue with it.

In 2000, Riva and his team[12] tested the efficacy of VR in modifying body image disturbances also in patients with obesity, binge eating disorder (BED), and eating disorder not otherwise specified (ED-NOS). Fifty-seven women who contacted the Weight Reduction Unit of the Istituto Auxologico Italiano were assessed before and after being treated by means of a brief VR therapy consisting of five fortnightly sessions. The measures used to assess body image disturbances showed a significant post-treatment improvement. Furthermore, the authors note that this improvement led, in turn, to a reduction in disturbed behaviors related to food and social relationships.

The results of these studies allowed Riva and his team to develop the *Experiential Cognitive Therapy* (ECT), which uses an enhanced version of the VEBIM in combination with cognitive-behavioral treatment (CBT) and psychoeducation. Since 2007, VEBIM has been included in NeuroVR (www .neurovr.org), a free VR platform based on open-source software.[13–15]

ECT is a relatively short-term (8–12 weeks) patient-oriented approach that focuses on individual discovery. As in the case of cognitive-behavioral therapy, ECT uses a combination of nutritional, cognitive, and behavioral procedures to help the patient identify and change the maintaining mechanisms in both obesity and eating disorders. However, ECT differs from the typical cognitive-behavioral approach in the VR body image rescripting protocol based on the *Allocentric Lock hypothesis*[16–22] in its focus on empowerment and in its focus on the negative emotions related to both body and eating.

According to this hypothesis, eating disorder (ED) and obesity may be the outcomes of a primary disturbance in the way the body is experienced and remembered: individuals with these disorders may be locked into an allocentric (ob-server view) image schema of their body that is no longer updated by contrasting egocentric representations driven by perception. This situation usually has one of two effects: either the subjects turn to more radical dietary restraint or they decide to stop any form of food control and engage in disinhibited eating behaviors. The shift from a locked allocentric representation to an eating or weight disorder may be explained by social influence since the media and culture promote dieting as the best way to improve one's body image satisfaction. However, the impossibility of improving body image, even after a demanding diet, locks the patient into an unsatisfying body.

In this view, the added value of VR lies in the possibility of altering the contents of the stored negative memory of the body.[20]

Riva et al. have published several case studies[23,24] and controlled studies[23–26] about the application of ECT to different weight-related disorders.

In 2001, Riva et al. divided 28 obese women into two equal groups to compare the results obtained from the application of two different treatments: one based on ECT and another on the psychonutritional intervention of traditional CBT. Both groups also took part in a parallel diet and exercise program. The results showed that treatment using ECT was more effective than CBT in improving body satisfaction, self-efficacy, and motivation for change, as well as in reducing overeating and reported anxiety. A later study by the same team[23] found similar results with 20 BED patients. Intervention based on ECT was more effective in the short term than was CBT in improving the overall psychological state of patients and, specifically, in increasing body satisfaction, self-efficacy, and motivation for change. However, no differences were found with regard to the reduction of binge eating behavior.

A year later, Riva et al.[24] randomly divided a sample of 36 women with binge eating disorder into three groups according to the type of treatment received: experiential cognitive therapy, including VR (ECT group), cognitive-behavioral therapy alone (CBT group), and the nutritional psychoeducation group. At 6-month follow-up, 77 percent of people in the ECT group had stopped bingeing compared with 56 percent and 22 percent in the CBT and nutritional psychoeducation groups, respectively. In 2006, Riva provided new evidence for the efficacy of ECT in the treatment of obesity.[26] On this occasion, the sample comprised 211 obese women (aged 18 to 50 years and body–mass index [BMI] over 40) without any other serious psychiatric disorder and who had suffered at least one relapse after treatment for obesity. The women were randomly assigned to one of three groups: ECT, traditional CBT, or nutritional psychoeducation. As in previous studies, the ECT group not only obtained better outcomes than the other two groups in terms of reduced body dissatisfaction and increased self-efficacy but they also had fewer relapses both at 6- and 12-month follow-up.[21]

The advantage of ECT in these patients is that during the VR exposure, they experience critical situations related to relapse in real life. In virtual environments, the user can face and learn to cope in such a situation, which, in addition to allowing the body image disturbance to be treated, increases the user's sense of self-efficacy.

In a final study, Cesa et al.[27] compared within a controlled study the outcome of 90 obese (BMI >40) female patients with

BED upon referral to an obesity rehabilitation center. As before, they were randomly assigned to three conditions: ECT, traditional CBT, or nutritional psychoeducation. At start, upon completion of the inpatient treatment and at 1-year follow-up, patients' weight, number of binge eating episodes during the previous month, and body satisfaction were assessed by self-report questionnaires and compared across conditions. The results showed that only ECT was effective at improving weight loss at 1-year follow-up. Conversely, control participants regained on average most of the weight they had lost during the inpatient program. Binge eating episodes decreased to zero during the inpatient program, but were reported again in all the three groups at 1-year follow-up. However, a substantial regain was observed only in the group that received the nutritional psychoeducation alone, while both ECT and CBT were successful in maintaining a low rate of monthly binge eating episodes.

Perpiñá et al.,[28] in Spain, developed another application for the treatment of ED, which was tested in a controlled study with a clinical sample (patients with anorexia nervosa [AN] and bulimia nervosa [BN]). With this objective, the researchers combined three treatment components:

- An adaptation of the body image disturbance treatment of Cash[29] and Rosen,[30] consisting of psychoeducation, exposure, intervention on safety behaviors, cognitive restructuring, and self-esteem related to the body. This cognitive-behavioral program was developed for eight weekly group sessions of 3 hours each.
- A VR component, applied in parallel to the body image treatment over six, weekly individual sessions of 1 hour each.
- A relaxation component, again implemented in parallel to the treatment for body image disturbances over six, weekly individual sessions of 1 hour each. This final component was added to balance the duration of therapy in both conditions so that all the patients received the same number of hours of treatment.

Eighteen outpatients diagnosed with having ED (anorexia nervosa or bulimia nervosa) were randomly assigned to two treatment conditions: the VR condition (CBT + VR) and the standard treatment for body image disturbances (CBT + relaxation). Thirteen of the 18 patients completed treatment and a significant improvement was observed in all of them. However, those who were treated with the VR component showed a significantly greater improvement in specific body image variables (highest level of satisfaction with their body in social situations, fewer thoughts and negative attitudes toward the body, less afraid of their weight, and less fearful of achieving a healthy weight). It should also be noted that the dropout rate was lower in the VR group, indicating increased motivation and adherence to treatment.

These results show that greater improvement was achieved with the addition of the VR component compared with the standard body image treatment alone. Given this, the researchers offered the patients in the standard treatment group the possibility of being treated with the VR component as well. The sample in this second study comprised 12 patients (7 with AN and 5 with BN). The results showed that the improvement achieved after completing the treatment was not only maintained after 12 months but also actually increased.[31] Similarly, a case study by the same authors[32] also reported an improvement in the ED patient's symptomatology at 1-year follow-up. Salorio del Moral et al.[33] published another case study in which they applied a 10-session treatment program based on the treatment developed by Perpiñá and her team to an AN patient. The authors reported decreased body dissatisfaction, better interoceptive awareness, less perfectionism, and no tendency toward asceticism in the treated participant. Furthermore, at 1-year follow-up, the patient showed no drive for thinness, more body satisfaction, and less interpersonal distrust, while perfectionism, asceticism, and social insecurity were all absent.

Perpiñá et al.[32] conducted a study with a small sample of ED patients (five with BN and four with binge eating [BE]) with the aim of analyzing the use of virtual environments to assess and treat binge eating episodes. The virtual environment presented to participants was the kitchen area, where forbidden (high-calorie) and permitted (low-calorie) food could be found. Participants were then asked to eat the forbidden food, usually a pizza. While they carried out this task, the experimenter suggested flavors and sensations. The results showed that the virtual environment was able to provoke the undesirable features present in binge eating episodes. First, once a forbidden food had been eaten, patients reported anxiety, an impulse to overeat, and guilt feelings (from moderate to extreme). Furthermore, all the patients said they experienced a strong sense of reality in the virtual environment. Second, introduction of the food smell during VR exposure led to an increase on all measures, indicating that augmented reality is useful for the purpose of helping participants to immerse themselves in the virtual situation and experience it more intensely. It should be remembered that the VR serves not only to recreate situations but also to help patients cope with mental representations of their fears.

VR technology has been also used to increase adherence to physical activity in obese individuals. Ruiz et al.[34] exposed 30 overweight and obese participants to three versions of a 3D avatar-based VR intervention to promote exercise: virtual representation of the self-exercising condition; virtual representation of other person exercising; and control condition. Results showed that only participants in the virtual representation of the self group significantly increased their levels of physical activity after intervention.

Another recent line of research is trying to assess the usefulness of VR for implementing exposure with response prevention of bingeing. Several treatment approaches have proved effective in the treatment of bulimia nervosa, and cognitive-behavioral therapy produces the best outcomes. However, some patients show resistance to conventional treatment and do not improve, despite intervention. The aim of this new line of research[35] is to develop a new treatment method based on cue exposure through VR. The novelty of this proposal is the addition of VR to cue-exposure procedures, which have proved effective in other studies.[36,37] This addition is aimed at increasing the efficacy of cue-exposure therapy through enhancing ecological validity, while decreasing the logistic complications associated with exposure to real cues (food).

Virtual reality and body image

A first use of VR technology in the field of weight-related disorders is in body image research: to improve our knowledge about the body image concept.

Recently, the team of Gutiérrez-Maldonado at the University of Barcelona (Spain) studied the instability of body image in women with anorexia and bulimia nervosa.

Previous research suggested that body image may be more a state than a trait[38–40] and may change according to situational or emotional variables.[41] In fact, Myers and Biocca[42] referred to the instability of body image almost 20 years ago, and more recently, other authors[43–45] stressed that trait and state components coexist in this construct. The trait perspective pertains to intraindividual stability of body image. By contrast, the state perspective focuses on the existence of intrapersonal variability.

Continuing this line of research, Gutiérrez-Maldonado and colleagues[46,47] studied whether perceptual distortions in body image and body dissatisfaction changed depending on the situation. The results showed that patients with ED display a significantly higher overestimation of body size after eating high-calorie food than after eating low-calorie food. In contrast, participants without ED showed similar percentages of overestimation in both situations. The general percentages of overestimation were much higher in the ED group than in the control group. The presence or absence of people in the virtual environments had no significant effect on body image distortion. Similarly, patients with ED showed significantly higher percentages of body dissatisfaction after eating high-calorie food than after eating low-calorie food. Once again, participants without ED showed similar body dissatisfaction in both situations. There was no significant effect for the variable people. The authors conclude that body image distortion and body image dissatisfaction change depending on the situation to which participants are exposed, provided this situation is emotionally significant for them. These results suggest that body image can indeed be understood as a state rather than as a trait, it being modified when the participant is exposed to situations that are emotionally relevant for them. Moreover, this study shows that food type appears to be an emotionally significant stimulus for patients with ED, one that is capable of producing changes in their body image, whereas the presence or absence of people has no such effect. Thus, body image distortion and body image dissatisfaction can be influenced by situational factors, and VR exposure is a useful technology for their study.

The evidence that body image disturbances act partially as a state is important and has therapeutic implications. Changing the body image experience of ED patients is one of the most difficult therapeutic goals to achieve,[48] and yet traditional treatment programs usually devote fewer sessions to this component than to disturbed eating behavior.[31,49] However, by using different virtual scenarios, which represent a range of stressful real-life situations for ED patients, the inclusion of body image assessment could provide clear and therapist-independent information about the subjective view that patients have of their bodies as their perception and judgments change depending on the situation they have been exposed to. This would offer patients with ED hard evidence that their body image is just a mental representation, which may differ greatly from objective reality.

VR and Emotions

Several studies have shown that *in vivo* exposure to food produces emotional responses in ED patients.[50,51]

To delve further into this issue with VR methodology, Gutiérrez-Maldonado et al. designed a multistage research project. In the first stage,[52,53] they studied the usefulness of VR for developing life-like virtual exposure environments capable of eliciting emotional responses in patients with ED. Six VR environments were developed using the information obtained from a survey of 68 patients with ED, who were asked about the situations and specific aspects of these situations that caused them discomfort related with body image. Unlike the conventional methods (e.g., *in vivo* exposure to the situation, exposure to photographs, and exposure through guided imagination) such as those used in previous studies,[54–60] VR exposes subjects to interactive 3D environments that simulate real situations, thus offering high ecological validity as well as strict control over the variables. Furthermore, VR is able to include both distal (e.g., eating in a restaurant) and proximal cues (e.g., pizza). Participants in this study were 108 female students and 85 patients with eating disorders. The assessment was carried out in two stages. First, the Eating Attitudes Test-26[61] was administered and the BMI calculated. Second, participants visited the virtual training environment, a neutral situation in which they learned to use navigation keys and which served as a baseline. The next step involved the first administration of measures concerning anxiety (STAI-S),[62] depression (CDB),[63] and body image (BIAS).[64] Participants were then randomly exposed to the remaining virtual environments. In the interval between the presentation of each environment, anxiety, depression, and body image disturbances were assessed again.

Compared with controls, patients with ED showed higher levels of anxiety and a more depressed mood after visiting all the virtual environments. More specifically, they showed higher levels of anxiety and a more depressed mood after eating, especially high-calorie food, as well as after visiting the swimming pool. Controls showed higher levels of anxiety in the swimming pool than in the neutral room and a less depressed mood in the restaurant (under both the high-calorie and low-calorie conditions). In the remaining situations, they showed a similar mood state to that in the neutral room. The higher levels of anxiety among controls in the swimming pool were probably due to the fact that in this kind of situation, body image dissatisfaction and social comparison affect all women. Rodin et al. talk about normative discontent in women to explain this phenomenon.[65] With regard to the restaurant, the social contact in this setting seemed to improve the mood of controls, probably because it was a more enjoyable and stimulating situation for them.

The results obtained with both *in vivo* and VR exposure appear to be similar, and this is an extremely important finding since it indicates that these environments could be used for both evaluative and therapeutic purposes. Recently, Gorini et al.[66] tested the emotional reaction of 10 AN patients, 10 BN patients, and 10 healthy control subjects to real food, VR food, and photographs of food. Authors found that real food and VR food produced comparable emotional reactions in ED patients and that this reaction was stronger than the one produced by photographs of food.

Other studies have assessed the ability of VR to elicit emotional, cognitive, and behavioral responses in ED patients similar to those observed in real life. Perpiñá et al.[67] conducted a pilot study with a small sample of ED patients (five with BN and four with BED) with the aim of analyzing the use

of virtual environments to assess and treat binge eating episodes. The virtual environment presented to participants was the kitchen area, where forbidden (high-calorie) and permitted (low-calorie) food could be found. Participants were then asked to eat the forbidden food, usually a pizza. The results showed that the virtual environment was able to provoke the undesirable features present in binge eating episodes. First, once a forbidden food had been eaten, patients reported anxiety, impulse to overeat, and guilt feelings (from moderate to extreme). Furthermore, all the patients said they experienced a strong sense of reality in the virtual environment. Second, when augmented reality was added in a second VR exposure session (patients smelled an actual hot pastry for the duration of the virtual eating process), scores on all measures increased. Therefore, augmented reality seems useful for the purpose of helping participants to immerse themselves in the virtual situation and experience it more intensely.

In another study, Perpiñá et al.[68] explored the efficacy of VR in eliciting emotions, sense of presence, and reality of a virtual environment in 22 ED patients and 37 healthy eating individuals. The VRE (nonimmersive) consisted of a kitchen room where participants had to eat a virtual pizza. To assess the sense of presence and reality produced by the VRE, participants answered seven questions with a Likert scale (0–10) during the experience, and then filled out the Reality Judgment and Presence Questionnaire (RJPQ) and ITC-Sense of Presence Inventory (ITC-SOPI). The results showed that the VRE induced a sense of presence and was felt as real for both groups, without differences in the experience of ease with the VRE, sense of physical space, or the ecological validity assigned to the virtual kitchen and eating virtually. However, the ED patients reported paying more attention and experiencing greater emotional involvement and dysphoria after virtual eating. The results suggest that the VRE was clinically meaningful to the ED patients.

It is interesting to note that VR exposure also produces emotional responses in a subclinical population. In a first study with 60 normal weight nondieting women, Ledoux et al. investigated whether food-related cues delivered by VR could induce greater food craving than neutral VR cues, photographic food cues, or real food.[69] Sixty normal weight nondieting women were recruited and, to prevent a floor effect, half were primed with a monotonous diet. In this specific study, however, food cravings produced by VR were marginally greater than a neutral cue, not significantly different from picture cues, and significantly less than real food. The modest effects may have been due to quality of the VR system and/or measures of food cravings (i.e., self-report and salivation).

In fact, in a different study, Ferrer-Garcia and colleagues assessed the ability of different virtual environments to elicit anxiety and craving for food in a nonclinical sample.[70,71] Their results show that exposure to virtual environments provokes changes in reported craving for food. Specifically, high-calorie food cues are the ones that elicit the highest increases in craving.

In a different study, Aimé et al.[72] exposed 27 women to three virtual environments—the office (neutral environment), the restaurant (with high- and low-calorie food), and the swimming pool. Anxiety was measured before, during, and after immersions. Weight, shape, and food concerns, drive for thinness, and body dissatisfaction were also mea-

sured after immersions. The authors found that participants who showed elevated, but subclinical, concerns with their weight and shape ($n = 10$) showed significantly higher level of anxiety and weight concerns after visiting the restaurant and the swimming pool than visiting the neutral situation. On the other hand, participants who did not show concerns with their weight and shape ($n = 17$) did not show anxiety or concerns after visiting the restaurant and the swimming pool.

It is also possible to use the potential of VR to elicit social comparison tendencies. To do so, Guitard et al. assessed the emotional impact of exposure to avatars with different body shapes in a virtual bar.[73] Their sample consisted of 17 shape-concerned participants, assessed using physiological and self-reported measures during two experimental immersions. Preliminary results support the hypothesis that exposure to both stimuli generates emotional reactions, a reaction which is even more significant when confronted with a thin-ideal stimulus.

The evaluation of social comparison is also the goal of a different study by Persky and Eccleston.[74] These authors assessed the attitudes, beliefs, and interpersonal behavior elicited by a virtual female patient who was visibly either obese or nonobese in a sample of 76 clinical-level medical students. The results revealed more negative stereotyping, less anticipated patient adherence, worse perceived health, more responsibility attributed for potentially weight-related presenting complaints, and less visual contact directed toward the obese version of a virtual patient than the nonobese version of the patient.

In conclusion, the different studies discussed in this article show that VR environments are useful for producing similar responses to those observed in the real world. Therefore, these environments can be useful for studying intraindividual variability of body image disturbances.

Author Disclosure Statement

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References

1. Riva G, Melis L, Bolzoni M. Treating body image disturbances. Communications of the ACM 1997; 40:69–71.
2. Riva G. Virtual reality in psychological assessment: the body image virtual reality scale. Cyber Psychology and Behavior 1998; 1:37–44
3. Riva G, Melis L. (1997) Virtual reality for the treatment of body image disturbances. In Riva G, ed. *Virtual reality in neuro-psycho-physiology: cognitive, clinical and methodological issues in the assessment and rehabilitation.* Amsterdam: IOS Press, pp. 95–111.
4. Riva G, Melis L. Virtual reality for the treatment of body image disturbances. Studies in Health Technology and Informatics 1997; 44:95–111.
5. Perpiñá C, Botella C, Baños RM. (2000) *Imagen corporal en los trastornos alimentarios: evaluación y tratamiento mediante realidad virtual.* Valencia, Spain: Promolibro.
6. Baars B. (1988) *A cognitive theory of consciousness.* New York: Cambridge University Press.
7. Riva G, Bacchetta M, Baruffi M, et al. VREPAR 2: VR in eating disorders. Cyberpsychology and Behavior 1999; 2: 77–79.
8. Riva G. Modifications of body-image induced by virtual reality. Perceptual and Motor Skills 1998; 86:163–170.

9. Riva G. Virtual environment for body image modification: virtual reality system for treatment of body image disturbances. Computers in Human Behavior 1998; 14:477–490.

10. Riva G, Bacchetta M, Baruffi M, et al. (1998) Experiential cognitive therapy: a VR based approach for the assessment and treatment of eating disorders. In Riva G, Wiederhold BK, et al., eds. *Virtual environments in clinical psychology and neuroscience: method and techniques in advanced patient-therapist interaction.* Amsterdam: IOS Press, pp. 120–135.

11. Riva G, Bacchetta M, Baruffi M, et al. Experiential cognitive therapy in anorexia nervosa. Eating and Weight Disorders 1998; 3:141–150.

12. Riva G, Bacchetta M, Baruffi M, et al. Realtà virtual e trattamento dei disturbi del comportamento alimentare. Psicoterapia Cognitiva e Comportamentale 2000; 6:173–184.

13. Riva G, Gaggioli A, Villani D, et al. NeuroVR: an open source virtual reality platform for clinical psychology and behavioral neurosciences. Studies in Health Technology and Informatics 2007; 125:394–399.

14. Riva G, Carelli L, Gaggioli A, et al. NeuroVR 1.5—a free virtual reality platform for the assessment and treatment in clinical psychology and neuroscience. Studies of Health Technology and Informatics 2009; 142:268–270.

15. Riva G, Gaggioli A, Grassi A, et al. NeuroVR 2—a free virtual reality platform for the assessment and treatment in behavioral health care. Studies of Health Technology and Informatics 2011; 163:493–495.

16. Gaudio S, Riva G. Body image disturbances in anorexia: the link between functional connectivity alterations and reference frames. Biological Psychiatry 2013; 73:e25–e26.

17. Riva G. (2007) Virtual body, real pain: the allocentric lock hypothesis. In Zampini M, Pavani F, eds. *Body representation workshop* (online: www.cimec.unitn.it/events/brw/Poster/107_abs_GIUSEPPE_RIVA.pdf). Rovereto, Italy: Università degli Studi di Trento.

18. Riva G. The key to unlocking the virtual body: virtual reality in the treatment of obesity and eating disorders. Journal of Diabetes Science and Technology 2011; 5:283–292.

19. Riva G. Neuroscience and eating disorders: the allocentric lock hypothesis. Medical Hypotheses 2012; 78:254–257.

20. Riva G. Out of my real body: cognitive Neuroscience meets eating disorders. Frontiers in Human Neuroscience 2014; 8:236.

21. Riva G, Castelnuovo G, Cesa G, et al. (2012) Virtual reality for enhancing the cognitive behavioral treatment of obesity: a controlled study with one-year follow-up. Paper presented at the Medicine 2.0'12, Boston.

22. Riva G, Gaudio S. Allocentric lock in anorexia nervosa: new evidences from neuroimaging studies. Medical Hypotheses 2012; 79:113–117.

23. Riva G, Bacchetta M, Baruffi M, et al. Virtual-reality-based multidimensional therapy for the treatment of body image disturbances in binge eating disorders: a preliminary controlled study. IEEE Transactions on Information Technology in Biomedicine 2002; 6:224–234.

24. Riva G, Bacchetta M, Cesa G, et al. Six-month follow-up of in-patient experiential-cognitive therapy for binge eating disorders. Cyberpsychology and Behavior 2003; 6:251–258.

25. Riva G, Bacchetta M, Baruffi M, et al. Virtual reality-based multidimensional therapy for the treatment of body image disturbances in obesity: a controlled study. Cyberpsychology and Behavior 2001; 4:511–526.

26. Riva G, Bacchetta M, Cesa G, et al. Is severe obesity a form of addiction? Rationale, clinical approach, and con-

trolled clinical trial. Cyberpsychology and Behavior 2006; 9:457–479.

27. Cesa GL, Manzoni GM, Bacchetta M, et al. Virtual reality for enhancing the cognitive behavioral treatment of obesity with binge eating disorder: randomized controlled study with one-year follow-up. Journal of Medical Internet Research 2013; 15:e113.

28. Perpiñá C, Botella C, Baños RM, et al. Body image and virtual reality in eating disorders: is exposure to virtual reality more effective than the classical body image treatment? Cyberpsychology and Behavior 1999; 2:149–159.

29. Cash TF. (1996) The treatment of body image disturbances. In Thompson JK, ed. *Body image, eating disorders and obesity.* Washington, DC: American Psychological Association, pp. 83–107.

30. Rosen JC. (1997) Cognitive-behavioural body image therapy. In: Garner DM, Garfinkel PE, eds. *Handbook of treatment for eating disorders.* New York: Guilford Press, pp. 188–201.

31. Perpiñá C, Marco JH, Botella C, et al. Tratamiento de la imagen corporal en los trastornos alimentarios mediante tratamiento cognitivo-comportamental apoyado con realidad virtual: resultados al año de seguimiento. Psicología Conductual: Revista Internacional de Psicología Clínica y de la Salud 2004; 12:519–537.

32. Perpiñá C, Baños R, Botella C, et al. Virtual reality as a therapy tool: a case study on body image alteration disorders. Revista Argentina de Clínica Psicológica 2001; 10:227–241.

33. Salorio del Moral P, Gómez Sánchez R, Morales Moreno I, et al. La realidad virtual, una nueva herramienta terapéutica. Tratamiento de la imagen corporal en los trastornos alimentarios. Revista Electrónica Semestral de Enfermería 2004; 5:1–17.

34. Ruiz JR, Andrade AD, Anam R, et al. Using anthropomorphic avatars resembling sedentary older individuals as models to enhance self-efficacy and adherence to physical activity: psychophysiological correlates. Studies in Health Technology and Informatics 2012; 173:405–411.

35. Gutiérrez-Maldonado J, Ferrer-Garcia M, Riva G. VR cue-exposure treatment for bulimia nervosa. Studies in Health Technology and Informatics 2013; 191:21–25.

36. Schmidt U, Marks IM. Cue exposure to food plus response prevention of binges for bulimia: a pilot study. International Journal of Eating Disorders 1988; 7:663–672.

37. Jansen A. A learning model of binge eating: cue reactivity and cue exposure. Behaviour Reasearch and Therapy 1998; 36:257–272.

38. Slade PD, Brodie D. Body Image distortion and eating disorder: a reconceptualitation based on recent literature. European Eating Disorders Review 1994; 1:32–46.

39. Smeets MAM. The rise and fall of body size estimation research in anorexia nervosa: a review and reconceptualization. European Eating Disorders Review 1997; 5:75–95.

40. Thompson JK, ed. (1996) *Body image, eating disorders, and obesity: an integrative guide for assessment and treatment.* Washington, DC: American Psychological Association.

41. Cash TF, Fleming EC, Alindogan J, et al. Beyond body image as a trait: the development and validation of the body image states scale. Eating Disorders: The Journal of Treatment and Prevention 2002; 10:103–113.

42. Myers PN, Biocca FA. The elastic body image: the effect of television advertisement and programming on body image distortions in young women. Journal of Communication 1992; 42:108–133.

43. Etu SF, Gray JJ. A preliminary investigation of the relationship between induced rumination and state body image dissatisfaction and anxiety. Body Image 2010; 7:82–85.

44. Lattimore P, Hutchinson R. Perceived calorie intake and state body-image satisfaction in women attempting weight loss: a preliminary investigation. Body Image 2010; 7: 15–21.

45. Rudiger JA, Cash TA, Roehrig M, et al. Day-to-day bodystates: prospective predictors of intra-individual level of variability. Body Image 2007; 4:1–9

46. Gutiérrez-Maldonado J, Ferrer-García M, Caqueo-Urízar A, et al. Body image in eating disorders: the influence of exposure to virtual environments. Cyberpsychology and Behavior 2010; 13:521–531.

47. Ferrer-Garcia M, Gutiérrez-Maldonado J. Effect of the mood produced by virtual reality exposure on body image disturbances. Studies in Health Technology and Informatics 2010; 154:44–49.

48. Rorty M, Yager J, Rossotto E. Why and how do women recover from bulimia nervosa? The subjective appraisals of forty women recovered for a year or more. International Journal of Eating Disorders 1993; 14:249–260.

49. Rosen JC, Ramírez E. A comparison of eating disorders and body dysmorphic disorder on body image and psychological adjustment. Journal of Psychosomatic Research 1998; 44:441–449.

50. Fett AK, Lattimore P, Roefs A, et al. Food cue exposure and body image satisfaction: the moderating role of BMI and dietary restraint. Body Image 2009; 6:14–18.

51. Schienle A, Schäfer A, Hermann A, et al. Binge-eating disorders: reward sensivity and brain activation to images of food. Biological Psychiatry 2009; 65:654–661.

52. Gutiérrez-Maldonado J, Ferrer-García M, Caqueo-Urízar A, et al. Assessment of emotional reactivity produced by exposure to virtual environments in patients with eating disorders. Cyberpsychology and Behavior 2006; 9: 507–513.

53. Ferrer-García M, Gutiérrez-Maldonado J, Caqueo-Urízar A, et al. The validity of virtual environments for eliciting emotional responses in patients with eating disorders and in controls. Behavior Modification 2009; 3:830–854.

54. Crisp AH, Kalucy RS. Aspects of the perceptual disorder in anorexia nervosa. British Journal of Medical Psychology 1974; 47:349–361.

55. McKenzie SJ, Williamson DA, Cubic BA. Stable and reactive body image disturbances in bulimia nervosa. Behavior Therapy 1993; 24:1958–2220.

56. Wardle J, Foley E. Body image: stability and sensitivity of body satisfaction and body size estimation. International Journal of Eating Disorders 1989; 8:55–62.

57. Carter F, Bulik CM. Exposure treatments for bulimia nervosa: procedure, efficacy, and mechanisms. Advances in Behavior Research and Therapy 1994; 16:77–129.

58. Heilbrun AB, Flodin A. Food cues and perceptual distortion of the female body: implications for food avoidance in the early dynamics of anorexia nervosa. Journal of Clinical Psychology 1989; 45:843–851.

59. Laberg JC, Wilson GT, Eldredge K, et al. Effects of mood on heart rate reactivity in bulimia nervosa. International Journal of Eating Disorders 1991; 10:169–178.

60. Haimovitz D, Lansky LM, O'Reilly P. Fluctuations in body satisfaction across situations. International Journal of Eating Disorders 1993; 13:77–84.

61. Garner DM, Olmsted MP, Bohr Y, et al. The Eating Attitudes Test: psychometric features and clinical correlates. Psychological Medicine 1982; 12:871–878.

62. Spielberger CD, Gorsuch RL, Lushene RE. (1970) *Handbook of STAI*. Palo Alto, CA: Consulting Psychologist Press [Spanish adaptation: Seisdedos N. (1988). Barcelona: Ediciones TEA].

63. Pérez B, Gutiérrez-Maldonado J, Ferrer-García M. Cuestionario de depresión Barcelona: evaluación del curso de la depresión. In *VII European Conference on Psychological Assessment*. Málaga, Spain. April 2004.

64. Ferrer-García M, Gutiérrez-Maldonado J. Body image assessment software: psychometric data. Behavior Research Methods 2008; 40:394–407.

65. Rodin J, Silberstein L, Striegel-Moore R. Women and weight: a normative discontent. Nebraska Symposium on Motivation 1984; 32:267–307.

66. Gorini A, Griez E, Petrova A, et al. Assessment of emotional responses produced to real food, virtual food and photographs of food in patients affected by eating disorders. Annals of General Psychiatry 2010; 9:30.

67. Perpiñá C, Botella C, Quero S, Marco H, Baños R. Design of clinically significant virtual-environments for binge eating episodes. In *VII European Council on Eating Disorders*. Barcelona, Spain. September 2001.

68. Perpiñá C, Roncero M, Fernández-Aranda F, et al. Clinical validation of a virtual environment for normalizing eating patterns in eating disorders. Comprehensive Psychiatry 2013; 54:680–686.

69. Ledoux T, Nguyen AS, Bakos-Block C, et al. Using virtual reality to study food cravings. Appetite 2013; 71:396–402.

70. Ferrer-Garcia M, Gutierrez-Maldonado J, Pla J. Cue-elicited anxiety and craving for food using virtual reality scenarios. Studies of Health Technology and Informatics 2013; 191:105–109.

71. Ferrer-Garcia M, Gutiérrez-Maldonado J. (2013) Cue-elicited craving for food in virtual reality. *Proceedings of the ACM Symposium on Virtual Reality Software and Technology*. VRST, Singapore, p. 268.

72. Aimé A, Cotton K, Bouchard S. Reactivity to virtual reality immersions in a subclinical sample of women concerned with their weight and shape. Journal of Cybertherapy and Rehabilitation 2009; 2:111–120.

73. Guitard T, Aime M, Bouchard SC, et al. Body dissatisfaction: eliciting emotions by social comparison in a virtual bar. Journal of Cybertherapy and Rehabilitation 2011; 4:295–297.

74. Persky S, Eccleston CP. Medical student bias and care recommendations for an obese versus non-obese virtual patient. Int J Obes (Lond) 2011; 35:728–735.

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