Chapter 7
Virtual Reality in the Assessment and Treatment of Weight-Related Disorders

Giuseppe Riva, José Gutiérrez-Maldonado, Antonios Dakanalis, and Marta Ferrer-García

Introduction

The use of Virtual Reality (VR) in behavioral health has become widespread (Riva 2005; Riva et al. 2016a, b). Recently, a paper assessed the 27 available reviews and meta-analyses exploring the efficacy of VR in this field (Riva et al. 2016a, b). The authors' findings supported the use of this technology for the treatment of anxiety disorders, stress-related disorders, pain management, and eating and weight disorders. In particular, three different randomized controlled trials (Cesa et al. 2013; Gutiérrez-Maldonado et al. 2016a, b; Marco et al. 2013) have shown at one-year follow-up that VR had a higher efficacy than the gold standard in the field, i.e., cognitive behavioral therapy (CBT) in treating eating disorders (ED) and obesity.

This vision also is shared by three different reviews of the field that were published recently (Ferrer-Garcia and Gutierrez-Maldonado 2012; Ferrer-Garcia et al. 2013a, b; Koskina et al. 2013). For example, the review by Ferrer-Garcia and colleagues (2013) stated: "There is fair evidence for the effectiveness of VR-based treatments in relation to body image disturbance in ED and obesity." Similarly, Koskina et al. (2013) suggested that VR exposure therapy "may be a useful

G. Riva (✉)
Università Cattolica del Sacro Cuore, Milan, Italy

Istituto Auxologico Italiano, Milan, Italy
e-mail: giuseppe.riva@unicatt.it

J. Gutiérrez-Maldonado · M. Ferrer-García
University of Barcelona, Barcelona, Spain

A. Dakanalis
University of Pavia, Pavia, Italy

University of Milan-Bicocca, Milan, Italy

A. Rizzo, S. Bouchard (eds.), *Virtual Reality for Psychological and Neurocognitive Interventions*, Virtual Reality Technologies for Health and Clinical Applications, https://doi.org/10.1007/978-1-4939-9482-3_7

intervention for ED, and its implementation is recommended either as a standalone treatment or as an intermediary step prior to *in vivo* exposure."

In fact, the clinical use of VR with these disturbances is based on key theory-driven psychological treatment techniques. First, VR can reduce eating-related anxiety during and after exposure to virtual food, helping to disrupt the reconsolidation of adverse, food-related memories (Koskina et al. 2013; Pla-Sanjuanelo et al. 2015). Second, a recent neuroscientific model of body image disturbances – the Allocentric Lock Theory – suggested that eating disorders may be associated with impairment in the ability to update a stored, negative allocentric (offline) representation of one's body with real-time (online/egocentric), perception-driven inputs (Dakanalis et al. 2016; Riva 2014). As demonstrated by two of the above RCTs (Cesa et al. 2013; Gutiérrez-Maldonado et al. 2016a), the addition of VR sensory training to unlock the body memory (body image rescripting protocol) by increasing the contribution of new, egocentric/internal, somatosensory information directly related to the existing allocentric memory was able to improve the efficacy of CBT at one-year follow-up.

Finally, the evolution of VR technologies is now allowing multisensory bodily illusions such as the Full Body Illusions that offer illusory ownership over a virtual fake body (Keizer et al. 2016; Serino et al. 2016a; b). As demonstrated by two recent studies (Keizer et al. 2016; Serino et al. 2016a, b) these techniques are able to temporarily correct the individual's experience of distorted body shape and size that characterizes these pathologies.

The next paragraphs will try to deepen these points by starting from the role played by body image disturbances in the etiology of these disorders.

Do Eating Disorders and Obesity Have a Common Etiology?

Eating disorders and obesity are serious health concerns due to their diffusion and negative effects on public health.

The raising prevalence of weight-related disorders, is pushing eating disorder and obesity researchers to start a collaboration between the fields to address them. In particular, their effort is focused on the identification of risk factors that are shared between these weight-related disorders (Haines and Neumark-Sztainer 2006): apparently, unhealthful weight-control behaviors – such as fasting (going without eating for 24 h for weight control), vomiting or laxative abuse – are the common antecedents of both obesity and eating disorders (Haines and Neumark-Sztainer 2006; Johnston 2004; Neumark-Sztainer 2009; Neumark-Sztainer et al. 2006; Stice et al. 2008; Stice et al. 2005). For example Neumark-Sztainer and colleagues (Neumark-Sztainer et al. 2006), discussed the results of the Project EAT II (Eating Among Teens), a longitudinal study involving 2516 ethnically and socioeconomically diverse adolescents. They report that, 5 years later, the use of unhealthful weight-control behaviors increased six times the risk for binge eating with loss of

control, three times the risk for being overweight, and two to five times the risk for extreme weight-control behaviors such as the use of diet pills and self-induced vomiting. A similar result was found by Stice and colleagues (Stice et al. 2008): in a different longitudinal study fasting was the best predictor for the future onset, 5 years later, of binge eating and bulimia nervosa.

It is well known from epidemiological studies that childhood obesity has different ethnic, socioeconomic (compared with affluent white children, the poor Hispanic, white, and black children have 2.7, 1.9 and 3.2 times higher odds of obesity), and behavioral risk factors (Singh et al. 2008). Between the behavioral variables higher television viewing, and higher physical inactivity levels were all independently associated with higher obesity prevalence.

However, in a 4-year longitudinal study on 496 adolescent girls, Stice and colleagues (Stice et al. 2005) studied the psychological and behavioral risk factors able to predict the onset of obesity in adolescent girls. Their data show that participants who were on a weight-loss diet, or who used maladaptive compensatory behaviors for weight control at T1 of the study showed, 4 years later, an increased risk for obesity onset.

The Role of a Negative Body Experience in the Aetiology of Eating Disorders and Obesity

The present results have an important clinical implication: the evidence that youths practicing unhealthful weight-control behaviors are at higher risk for obesity and eating disorders implies that prevention and treatment interventions should also focus on the causes of these behaviors. In other words, why do adolescents decide to start such radical weight-control behaviors? In a recent letter to the *Women-health.com* site an adolescent girl wrote: "*I hate my body. No matter what I weigh I always look fat, how can I fix this? I am 5' 1' (156cms) and weigh 142 lbs (64.5 kg). My BMI is 26.1. In terms of getting back to a healthy weight, I only need to lose between 7 to 10 lbs (3–4 kg). But to look in the mirror, I look at myself and think that I'm extremely fat. My dietitian seems to think that my weight will normalise and by eating normally and exercising moderately that I should go back to a weight closer to 132 lbs (60 kg). However, even when I was that weight that I still looked horrendously overweight and disgusting*." (online: http://www.womens-health.com/boards/mental-health/32504-i-hate-my-body-no-matter-what-i-weigh-i-always-look-fat-how-can-i-fix.html).

The words of the girl clearly explain her behavior: she stopped eating properly because she does not like her body (Riva et al. 2000a, b). A study by Kostanski and Gullone (Kostanski and Gullone 1999) with a sample of 431 Australian pre-adolescent children (7–10 years) confirms this interpretation: pre-adolescents as young as 7 years of age are unsatisfied with their body appearance and deliberately engage in restrictive eating behaviors.

In general, between 50% and 80% of young women in developed countries want to be thinner and between 20% and 60% are dieting because they think they are fat and unattractive (Cash and Pruzinski 2004). Even normal-weight and underweight girls want to lose weight. These high percentages in the female population have led some authors to speak of the existence of a body experience "normative discontent" in this group (Rodin and Larson 1992). Indeed, men are usually less dissatisfied than women and may even show an increase in body satisfaction during adolescence. For girls, however, puberty only makes things worse. The normal physical changes – increase in weight and body fat, particularly on the hips and thighs, take them further from the cultural ideal of unnatural slimness.

Developing a Negative Body Representation

As we have just seen, a negative body experience during adolescence is an important predictor of eating disorders. Therefore, it is useful to identify the aspects related with its development. Personal, interpersonal and social factors must all be considered.

Personal factors include biological factors such as body mass index (BMI), sex and age, and psychological and personality characteristics. From early childhood, children are aware of the social preference for slender bodies and internalize the present aesthetic model of beauty, which is characterized by the idealization of an ever thinner female body. Likewise, children detect rejection of obese or overweight people. Consequently, overweight children show body dissatisfaction and express their desire to be thinner. Indeed, the BMI of girls correlates with reported body dissatisfaction. During adolescence, the feeling of dissatisfaction in girls increases; with the onset of puberty, they suffer substantial physical changes that involve an increase in their body volume and in the accumulation of fat in certain body parts. These changes do not conform to the ideal of thinness to which women aspire. By contrast, boys' dissatisfaction seems to fall during adolescence; as they gain height and volume, they come closer to the male aesthetic body model. Linda Smolak (2012) notes that differences between males and females with respect to dissatisfaction with one's own body representation and weight concerns are already present in children in elementary education.

Literature reports suggest that certain psychological and personality characteristics may be associated with an increased risk of developing a negative body representation. High levels of social anxiety and the tendency to compare with others may be associated with poor self-esteem in childhood and, consequently, with an increased risk of developing a negative body representation. As Cash and Pruzinski (2004) state, negative body image is correlated with low self-esteem, depression, anxiety, fear of negative evaluation and obsessive-compulsive tendencies.

With regard to **interpersonal factors**, parents and peers are the main contributors to the development of our body representations. Parents can influence in two ways: through comments made in relation to their children's appearance and the eating

habits that they inculcate in them, and through the example they offer with their own eating habits and the attitudes they show towards the body. Studies have shown that the comments of parents are related to their children's body dissatisfaction (Cash and Pruzinski 2004; Kim 2009). However, there are no clear data about the influence of parental modeling, although it seems that girls are more affected than boys, especially by maternal modeling (Smolak 2012).

Social comparison with peers plays an important role in children's development. By means of social comparison, they realize the ideals of beauty associated with weight and body shape, and become aware of the extent to which they conform to these ideals or not. However, it is during adolescence when peer influence exerts more pressure, especially in girls. A phenomenon that deserves special attention is teasing. Research shows that there is a close relationship between suffering gibes about body size and shape and the body image that young people develop (Sweetingham and Waller 2008). People who have suffered some kind of sexual abuse during adolescence also tend to show a more negative body image because of the feelings of shame and the perceived loss of control over the body that are experienced in these situations (Cash and Pruzinski 2004).

More, the **socio-cultural and economic** environment also plays an important role in the development of our body representation. We have already mentioned the importance of the female aesthetic body model currently in vogue in Western societies. This model has progressively reduced the ideal body size to below the average weight of women (Dakanalis et al. 2012). In the case of men, the aesthetic model promotes physical fitness and an athletic body rather than thinness. Moreover, women more often receive pressure than men to fit a certain aesthetic model. Many studies have shown how this pressure is exerted by the mass media (Dakanalis and Riva 2013). The slender body ideal and associated body dissatisfaction have usually been ascribed to Western societies or developed countries. However, such a beauty ideal and body concerns are now spreading to different social, economic and cultural settings as part of the globalization of Western beliefs, attitudes and practices. Consequently, body dissatisfaction and weight concerns are now present in most societies (Dakanalis et al. 2013a, b).

From a Negative Body Representation to the Development of Obesity and Eating Disorders

A popular socio-cultural model – the "objectification theory" introduced by Fredrickson and Roberts (Fredrickson and Roberts 1997) identifies in a negative body representation a key factor in the aetiology of these disorders. Specifically, this theory suggests that our culture imposes a specific orientational model – self-objectification – defining women's behavioral and emotional responses (Calogero 2012; Calogero et al. 2010) At its simplest, the objectification theory holds that (Dakanalis and Riva 2013; Riva 2014): (1) there is an societal ideal of beauty underlying the key role of a thin body that is (2) transmitted via a variety of

sociocultural channels. This ideal is then (3) internalized by individuals, so that (4) satisfaction and dissatisfaction with appearance will be a function of the extent to which individuals do (or do not) meet this ideal prescription. Different studies based on this theory have shown that exist strong links between self-objectification and eating disorder symptoms (Dakanalis et al. 2015, 2017; Monro and Huon 2006). Nevertheless, even if self-objectification is a key characteristic of our culture, only a small subset of all the female and male subjects exposed to idealized body models develops clinically diagnosable EDs (Thompson et al. 1999). Why?

A possible answer to this question is offered by the Allocentric Lock Hypothesis.

Recently, Riva and colleagues (Dakanalis et al. 2016; Gaudio and Riva 2013; Riva 2007, 2011, 2012; Riva et al. 2012; Riva and Gaudio 2012, 2018; Riva et al. 2015) have proposed the **allocentric lock hypothesis** as a synthesis of neurobiological, psychological and socio-cultural data about the etiology of both ED and obesity. The primary claim of the "*Allocentric Lock Hypothesis"* is that deficits in the integration of expected (from predictive coding) and experienced (from perception) bodily inputs are able to produce a disturbed body memory that does not only motivate severe dietary restrictions and other weight loss behaviors, but also may play a central part in initiation, persistence, and relapse of EDs. This perspective offers a powerful insight, according to which EDs subjects may indeed have a dysfunction in multisensory integration processes that does not allow them to modify their experience of the body even after a demanding diet or a significant weight loss (Riva 2018; Riva and Gaudio 2018).

The process linking the cultural pressure to be thin, to the allocentric lock induced by a multisensory integration deficit, to the development of an eating disorder is detailed in Fig. 7.1 and summarized below:

- Subjects in their social interactions develop a specific "body image" that defines the meaning of our objectified body. The content of the body image is related to cultural standard. For example, this may include "fat phobia" (fear of becoming fat) in Western countries, or "weight phobia" (fear of becoming mature) in Asian countries (Lee 1995).
- In Western countries, the value of the objectified body is defined more by observable body attributes (e.g., "How do I look?" – allocentric perspective), rather than by privileged, or nonobservable body attributes (e.g., 'What am I capable of?" "How do I feel?" – egocentric perspective).
- The endorsement and acceptance of appearance media ideals lead subjects to become aware of how their bodies looks and to evaluate themselves in terms of physical appearance. This evaluation becomes body surveillance, the tendency to be highly vigilant of one's appearance (Fitzsimmons and Bardone-Cone 2011).
- Subjects who experience one or more personal (e.g., "The new jeans were too tight") or social (e.g., teasing) situations in which they fail to meet physical appearance standards, then update the objectified body accordingly (van den Berg et al. 2007): e.g., "My body is fat". As demonstrated by different studies, including a recent meta-analysis (Makinen et al. 2012; Menzel et al. 2010),

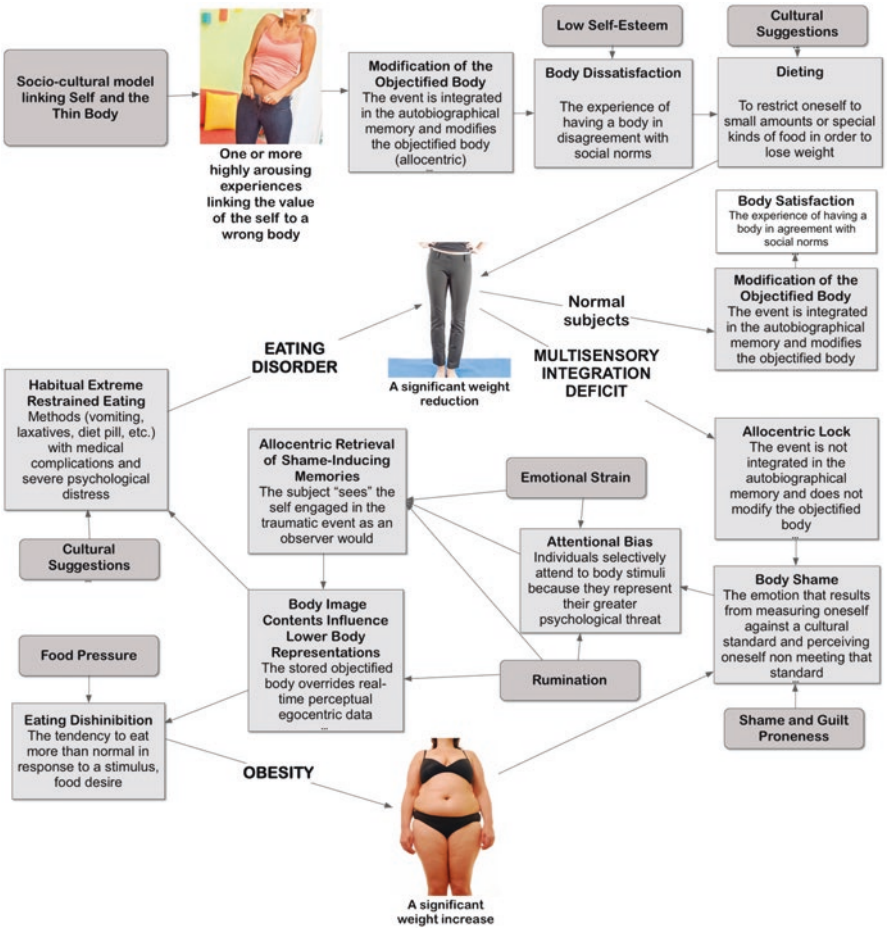

Fig. 7.1 The aetiology of eating disorders and obesity (Adapted from Riva 2014)

this produces body dissatisfaction, defined as displeasure with some aspect of one's appearance (Cash and Pruzinski 2004).

- Body dissatisfaction has a critical effect on eating behavior: subjects go on diet to improve the satisfaction with their body. According to the data collected by Ogden and colleagues from 8165 children and adolescents living in the United States (Ogden et al. 2008) about 62% of girls aged 12–19 report that they are trying to lose weight.
- Normally, after a successful diet, subjects experience a thinner body and again modify their objectified body accordingly (e.g., "I'm no more fat"). For a multisensory integration deficit (Riva and Gaudio 2018), however, subjects with eating disorders are locked into their negative objectified body: its content cannot updated even after a demanding diet and a significant weight loss.

- The impossibility of meeting societal standards transforms body dissatisfaction into body shame: the painful social emotion that can result from measuring oneself against a cultural standard and perceiving oneself as being judged and seen as inferior, defective or unattractive in the eyes of others (Dakanalis et al. 2013a, b; Pinto-Gouveia and Matos 2011).
- Body shame usually has two behavioral effects: subjects either start more radical dieting behaviors – such as the use of diet pills and self-induced vomiting – or, at the opposite, decide to stop any form of food control and start "disinhibited" eating behaviors (Van Strien et al. 2009). In particular, as samurai committed seppuku to remove shame, subjects are ready to use the most extreme weight reduction techniques – fasting, vomiting, laxatives, etc. – to achieve the same result.
- A variety of studies show that shame experiences are also recorded in autobiographical memory, influencing body image and self-relevant beliefs, inattentional and emotional processing (Pinto-Gouveia and Matos 2011). As demonstrated by numerous studies, in patients with eating disorders, the representation of the body included in the shame-inducing negative emotional event produces a priming effect on any body-related experience (Blechert et al. 2011; Goldfein et al. 2000): on one side, the tendency of our perception to be affected by our recurring thoughts produces an attentional bias on body related stimuli; on the other side, it draws the subject's attention to previously stored body image stimuli biasing egocentric perceptual data and the interpretation of future self-relevant events.

This situation potentially has three effects: experiential, cognitive and social (Riva 2014). The first, and probably most relevant consequence, is experiential: The permanent experience of a "wrong" body, totally independent by the shape or the size of the real body. In simpler words, these subjects cannot win: Whatever they will do to modify their real body, they will always be present in a virtual body (the objectified negative memory) that they hate. The second effect of the allocentric lock is cognitive: It reorganizes existing memories and produces a priming effect on any body related experience. The final consequence of the allocentric lock is social: Subjects attribute mental states to others by adopting an allocentric stance, striving towards static and sometimes unrealistic systems for understanding social relations.

The Use of Virtual Reality in the Study and Assessment of Weight-Related Disorders

To maximize the degree of control and internal validity, traditional experimental methods usually require participants to carry out tasks that are far removed from real-life activities. This means that the ecological validity of these tasks is questionable. On the other hand, studies based on field data, while having ecological validity, cannot control multiple confounding variables that may have an impact on observed

results, so that their internal validity is reduced. Virtual Reality provides a better balance between internal and ecological validity, since VR simulations can be completely controlled for experimental purposes and, at the same time, allow subjects to carry out tasks that are identical to those performed in real life. For this reason VR has been used to study different features of weight-related disorders.

Virtual Reality and Body Image

A first use of VR technology in the field of weight-related disorders is in body image research: **to broaden our knowledge of the body image concept and to aid the evaluation of body image disturbances**.

Riva conducted the pioneering studies on the application of VR for the assessment and treatment of body image disturbances (Riva et al. 1997) as part 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 BIVRS (Body Image Virtual Reality Scale; [Riva 1998a] and [Riva and Melis 1997a, b]). The BIVRS was a non-immersive, 3D graphical interface comprising nine figures, male and female, ranging from underweight to overweight. Participants were asked to choose the figures that best fit their self-perceived and their desired body size. Discrepancy between the two measures was an indicator of body image dissatisfaction. The BIVRS improved on traditional assessment methods based on silhouettes by adding the third dimension to the figures presented to the user: the increased realism of the figures made it easier for the participants to identify with them.

Perpiñá and colleagues went a step further with the development of an immersive VR-based application for the assessment of body image disturbance (Perpiñá et al. 2000). The assessment software consisted of a 3D human figure whose body parts could be modified using sliders. The main advantage of this application was that, as it is immersive, the modifiable figure was of a similar size to the user size and was placed in the same virtual position. Moreover, the software allows clinicians to assess several dimensions or indexes of body image (e.g., the perceived body, the desired body, the healthy body, etc.) and body weight (actual weight, subjective weight, healthy weight and desired weight), and all in different contexts.

To explore the concept of body image further, Gutiérrez-Maldonado and colleagues (Gutiérrez-Maldonado et al. 2010; Ferrer-Garcia and Gutiérrez Maldonado 2010) focused their attention on the study of body image instability in patients with anorexia and bulimia nervosa. Several studies have stressed that trait and state components coexist in the construct of body image (Etu and Gray 2010; Lattimore and Hutchinson 2010; Myers and Biocca 1992; Rudiger et al. 2007). According to the trait perspective, emotional and situational variables may produce changes in the way that people perceive and value their own body (Cash et al. 2002; Slade and

Brodie 1994; Smeets 1997; Thompson 1996). Continuing this line of research, Gutiérrez-Maldonado and colleagues (Gutiérrez-Maldonado et al. 2010; Ferrer-Garcia and Gutiérrez Maldonado 2010) used the ability of VR to reproduce everyday life environments in order to study whether body image disturbance in patients with eating disorders (ED) change depending on the situation.

The authors exposed 85 women with ED and 108 women without ED to different VR environments (kitchen and restaurant) containing different kinds of food (low-calorie versus high-calorie food) and in the presence or absence of other people (avatars). In accordance with the trait perspective, the authors found that ED patients showed a significantly higher over-estimation of body size after simulating eating high-calorie food than after simulating eating low-calorie food in the virtual environments. Likewise, ED patients reported significantly higher percentages of body dissatisfaction after the high-calorie food than after the low-calorie food simulation. In contrast, participants without ED showed similar body distortion and body dissatisfaction in both situations. For its part, the presence or absence of people in the virtual environments had no significant effect on body image.

Gutiérrez-Maldonado concluded that body image distortion and dissatisfaction change depending on the situation to which participants are exposed, provided this situation is emotionally significant for them. In his study, two variables were manipulated to induce an emotional response in participants: the kind of food and the presence of other people. As mentioned above, only food type proved to be an emotionally significant stimulus for patients with ED (one capable of producing changes in their body image), whereas the presence or absence of other people had no such effect.

The main interest of this study is that it provides evidence that body image distortion and dissatisfaction can be influenced by situational factors or, in other words, that body image disturbances act partially as a state. This assertion has important therapeutic implications. Indeed, one of the most difficult therapeutic goals for clinicians is to change the body image experience of ED patients (Rorty et al. 1993). Besides, treatment programs usually devote fewer sessions to this component than to disturbed eating behavior (Rosen and Ramírez 1998; Rosen 1997). However, by using different virtual scenarios representing a range of stressful real-life situations for ED patients, the inclusion of body image assessment could provide clear, therapist-independent information about the subjective view that patients have of their bodies, since 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 – which in itself would represent a starting point for accepting change.

Virtual Reality and Emotions

Virtual reality-based methods have also been used to assess the different responses of ED patients and healthy controls when exposed to certain stimuli and situations. Several studies show that exposure to food cues produces specific emotional and

behavioral responses in ED patients (e.g., Fett et al. 2009; Schienle et al. 2009). It has been suggested that if VR environments could induce similar responses to real stimuli in patients with ED, this technology could be used as a valid exposure technique in the assessment and treatment of eating disorders (Ferrer-Garcia et al. 2009). Unlike conventional methods (e.g., "in vivo" exposure, exposure to photographs, exposure via guided imagination, and so on), VR exposes individuals to interactive three-dimensional environments that simulate real situations, thus offering high ecological validity as well as strict control over the variables. Furthermore, VR allows researchers and clinicians to include both distal (e.g., restaurant) and proximal cues (e.g., pizza).

To test the usefulness of VR for developing life-like virtual exposure environments capable of eliciting emotional responses in ED patients, Gutiérrez-Maldonado and colleagues designed a multi-stage research project (Gutiérrez-Maldonado et al. 2006; Ferrer-Garcia et al. 2009). Six virtual reality 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. One hundred and eight healthy female students and 85 patients with a diagnosis of ED were exposed to the virtual environments (training room, kitchen with low-calorie food, kitchen with high-calorie food, restaurant with low-calorie food, restaurant with high-calorie food, and swimming pool). First, participants visited the virtual training room, a neutral situation in which they learned to use navigation keys and which served as a baseline, and the anxiety and depression experienced in this situation were assessed using the STAI-S (Spielberger et al. 1970) and the CDB (Pérez et al. 2004) respectively. Participants were then randomly exposed to the remaining virtual environments. In the intervals between the presentation of each environment, anxiety and depressed mood were assessed again.

Compared with healthy controls, patients with ED showed higher levels of anxiety and a more depressed mood after visiting all the virtual environments. The highest levels of anxiety and depressed mood were found after eating high-calorie food (in the kitchen and in the restaurant) and after visiting the swimming pool. On the other hand, healthy controls only showed increased anxiety (compared with the neutral room) in the swimming pool. Ferrer-Garcia et al. (2009) attributed this last result to the "normative discontent" in women (Rodin et al. 1984), according to which most women experience body image concerns in situations such as the swimming pool where the body is exposed and susceptible to social comparison.

In the same research line, Aimé and colleagues (Aimé et al. 2009) exposed 27 women to three virtual environments – the office (a neutral environment), the restaurant (with high- and low-calorie food), and the swimming pool – and measured anxiety before, during, and after immersions. Weight, shape, and food concerns, drive for thinness, and body dissatisfaction were also measured after immersions. The authors found that participants with 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) showed no anxiety or concerns after visiting the restaurant and the swimming pool.

The results of these studies suggest that VR exposure is able to produce similar responses in ED patients and healthy controls to those elicited in real situations and that it could therefore be used for both evaluative and therapeutic purposes. However, despite their promising results, these studies did not directly compare VR exposure with in vivo exposure. To overcome this drawback, Gorini et al. (2010) assessed the emotional reactions of 10 AN patients, 10 BN patients, and 10 healthy controls 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.

Perpiñá, Botella, Baños and colleagues also studied the ability of VR environments to elicit emotional, cognitive and behavioral responses in ED patients (Perpiñá et al. 2001; Perpiñá et al. 2013). This research group conducted a pioneering pilot study with a small sample composed of five patients with BN and four with BED, with the aim of analyzing the use of virtual environments to assess and treat binge eating episodes. Participants were exposed to a virtual kitchen, where they were asked to eat high-calorie food (e.g., pizza). The results showed that the virtual environment was able to provoke the undesirable features present in binge-eating episodes. Once a forbidden food had been eaten, patients reported anxiety, impulse to over-eat, and guilt feelings (from moderate to extreme). Furthermore, all the patients said they experienced a strong sense of reality in the virtual environment. Moreover, when augmented reality was added in a second VR exposure session (patients smelled a real hot pastry for the duration of the virtual eating process), scores on all measures increased.

More recently, Perpiñá et al. (2013) examined the ability of virtual environments to elicit sense of presence and judgment of reality in users. Twenty-two ED patients and 37 healthy eating controls were exposed to a non-immersive virtual environment, a kitchen in which participants had to eat a virtual pizza. Participants filled out the Reality Judgment and Presence Questionnaire (RJPQ) and the ITC-Sense of Presence Inventory (ITC-SOPI). The results showed that the VR environment induced a sense of presence and was felt to be real by both groups; however, the ED patients reported paying more attention and experiencing greater emotional involvement and dysphoria after virtual eating. The results suggest that the VR environments created were clinically meaningful to the ED patients.

Another interesting line of research has focused on the ability of VR environments to elicit food craving in ED patients and non-clinical samples. Ledoux and colleagues (Ledoux et al. 2013) assessed whether food-related cues delivered by VR induced greater food craving than neutral VR cues, photographic food cues, or real food in a sample of 60 normal-weight non-dieting women. The results showed that the food craving produced by VR was only marginally greater than craving elicited by neutral cues, not significantly different from picture cues, and significantly lower than real food. Ledoux suggested that these modest effects may have been due to the low quality of the VR system and/or measures of food craving

(i.e., self-report and salivation). In fact, contrasting results were found by Ferrer-Garcia and colleagues, who also assessed the ability of different virtual environments to elicit craving for food in non-clinical samples (Ferrer-Garcia et al. 2013a, b; Ferrer-Garcia et al. 2015a, b). These authors reported that exposure to high-calorie food in virtual environments provoked significantly higher levels of food craving than low-calorie food virtual cues. In view of the evidence of the effectiveness of food-related VR environments to elicit food craving and emotional responses in ED patients, this research group started a new line of study assessing food craving in ED patients using VR-based exposure.

With this objective in mind, Pla-Sanjuanelo et al. (2017) developed a VR-based software for cue exposure therapy in patients with bulimia nervosa (BN) and binge eating disorder (BED). As a previous stage before using the software with therapeutic intent, these authors tested its ability to elicit anxiety and food craving in ED patients, and assessed differences with respect to the responses of healthy controls. Fifty-eight ED outpatients (33 BN and 25 BED) and 135 non-clinical participants were exposed to 10 craved virtual foods (e.g., chocolate) and a neutral cue (a stapler) in four experimental virtual environments (kitchen, dining room, bedroom, and cafeteria). After exposure to each VR scenario, food craving and anxiety were assessed. In both groups, craving and anxiety responses when exposed to the food-related virtual environments were significantly higher than in the neutral-cue virtual environment; however, craving and anxiety levels were significantly higher in the clinical group. Thus, these results supported the usefulness of VR for eliciting food craving in ED patients and its ability to discriminate between clinical and non-clinical participants.

Interestingly, an association has also been found between participants' eating behavior style (emotional, restrictive, or external; Van Strien et al. 1986) and food craving levels reported in the virtual environments (Ferrer-Garcia et al. 2015b; Ferrer-Garcia, Pla-Sanjuanelo et al. 2017). Analyzing the effect of eating style on the anxiety and food craving reported in the study by Pla-Sanjuanelo et al. (2017) mentioned above, Ferrer-Garcia et al. (Ferrer-Garcia et al. 2017a) found that, in the healthy group, external eating was the only predictor of cue-elicited craving and anxiety, whereas in participants with BN and BED external and emotional eating were the best predictors of cue-elicited craving and anxiety respectively. Based on these data, the authors suggested that VR-based cue-exposure therapy may be an ideal intervention for ED patients with an external eating style.

Finally, the potential usefulness of VR to elicit social comparison tendencies has also been investigated. Guitard and colleagues assessed the emotional impact of exposure to avatars with different body shapes in a virtual bar on 17 body shape-concerned participants, using physiological and self-reported measures (Guitard et al. 2011). Their results provided preliminary support for the hypothesis that social comparison in virtual environments produces emotional reactions in participants, especially when confronted with a thin-ideal stimulus.

In conclusion, the studies discussed in this section show that VR environments are able to produce responses similar to those observed in real world.

The Use of Virtual Reality in the Treatment of Weight-Related Disorders

As noted above, body image disturbance is one of the most difficult features of ED and obesity to modify. The cognitive-behavioral approach (Butters and Cash 1987) has proved to be effective for its treatment and is the most frequently used intervention. Alternatively, visual-motor therapy, whose main objective is to increase subjects' awareness of their own body by videotaping and subsequently viewing the different gestures and body movements, has also showed promising results (Wooley and Wooley 1985). Both kinds of intervention are useful, but body image disturbances are highly persistent (Vandereycken 1990; Vandereycken et al. 1988); in this context, VR offers an innovative and promising complement to traditional methods of intervention.

Virtual Reality in the Treatment of Body Image-Related Disturbances

Riva and colleagues (Riva and Melis 1997a, b; Riva et al. 1997) developed the first VR-based application for the treatment of body image disturbance in weight-related disorders: the VEBIM (Virtual Environment for Body Image Modification). The VEBIM consisted of five virtual reality environments or zones grouped into two parts. The first part (Zone 1: training room and balance; and Zone 2: kitchen and office) was developed so that users could acquire the minimum skills necessary to navigate and interact with the environment, and to identify which stimuli were able of eliciting disturbed eating behaviors. Three additional virtual areas (Zone 3: pictures of models; Zone 4: the mirror room; and Zone 5: the room of doors) were developed to modify the user's body image. During exposure to different environments the Socratic Method was used to help participants to challenge distorted thoughts about their body weight and shape, and to develop a more realistic perception of their own body image (Riva et al. 1998a, b).

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 is a cognitive bias (see also the paragraph on the Allocentric Lock Hypothesis) and, as such, it is barely accessible to consciousness. This fact hinders body image change, as users believe that biased information is real (Riva 2003). However, due to the intrinsic features of the technology the virtual experience gives users access to this unconscious information related with body schemata, where the latter refers to the model of their own body that individuals have developed and which serves as the basis for judging their movement and posture (Head 1926). 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 propioceptive 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 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 (Baars 1988). 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-behavioural 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" (Riva et al. 1999, p. 78).

Riva (1998a; b; c; Riva and Melis 1997b) conducted some preliminary studies with non-clinical population to assess the VEBIM. In the first of these studies, exposure to VEBIM during no more than 10 mins produced changes on body image dissatisfaction (understood as the discrepancy between the perceived and the ideal body size). Specifically, body dissatisfaction levels were significantly lower after leaving the VEBIM than before entering. A controlled study was conducted subsequently in order to test the results obtained in the first one. Here, 48 women were randomly assigned to two groups: the experimental group, in which the VEBIM was administered, and the control group, without treatment. In line with the first study the experimental group showed a significant reduction in body image dissatisfaction after visiting the VEBIM compared with previous measures. The control group did not show any significant change across the two measures. Riva (1998c) also studied whether exposure to VEBIM produced psychophysiological changes in a sample of 47 males and 24 females. Blood pressure and heart rate were assessed. No differences were found between measures obtained before and after the virtual experience. Given the results of those preliminary studies, Riva and colleagues (Riva et al. 1998a, b, 1999) 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 (Riva et al. 2000a, b, c) tested the efficacy of VR in modifying body image disturbances also in patients with obesity, BED and 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 and psychoeducation (see Table 7.1). Since 2007 VEBIM has been included in NeuroVR 2 (http://www.neurovr.org, see Fig. 7.2) a free virtual reality platform based on open-source software (Riva et al. 2007, 2009, 2011).

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

Table 7.1 The structure of the Experiential-Cognitive Therapy – ECT (Adapted from Riva et al. 2004, 2006)

Week 1	
Psychometric test (Test)	
Psychodiagnostic Interview	Preliminary group (Motivation to treatment and definition of rehabilitative protocol)
Session 1 VR Assessment + body image (virtual balance + sitting room)	Nutritional assessment
Weeks 2 and 3	
Session 2 VR Eating control + interpersonal reframe (kitchen + bathroom + bedroom)	Nutritional group (2/3 sessions)
Session 3 VR Body image (BIVRS)	Psychological Group (1 session)
Session 4 VR Eating control (supermarket)	Physical Activity
Weeks 4 and 5	
Session 5 VR Body image + interpersonal reframe (gymnasium)	Nutritional group (2/3sessions)
Session 6 VR Eating control + interpersonal reframe (pub)	Psychological group (1 session)
Session 7 VR Body image + interpersonal reframe (clothes shop)	Physical activity
Weeks 6 and 7	
Session 8 VR Eating control + interpersonal reframe (restaurant)	Nutritional group (2/3sessions)
Session 9 VR Body image + interpersonal reframe (swimming pool + beach)	Psychological group (1 session)
Session 10 VR Eating control + body image (kitchen + BIVRS + 9 doors room)	Physical activity
Week 8	
	Psychological support (2/3 sessions)
	Physical activity
	Final group (motivation to out-patient phase)
Psychometric tests (Re-test)	

eating disorders. However, ECT differs from the typical cognitive-behavioral approach in the VR body image rescripting protocol based on the Allocentric Lock hypothesis (see Table 7.2), in its focus on empowerment and in its focus on the negative emotions related to both body and eating.

Riva and colleagues have published several case studies (Riva et al. 2002; 2003) and controlled studies (Riva et al. 2001; 2002; 2003; 2006) about the application of ECT to different weigh-related disorders.

Table 7.2 *The VR body image rescripting protocol* (Adapted from Riva 2011)

Phase 1: Interview	During a clinical interview the patient is asked to relive the contents of the allocentric negative body image and the situation/s in which it was created and/or reinforced (e.g. being teased by my boyfriend at home) in as much detail as possible. The meaning of the experience for the patient was also elicited.
Phase 2: Development of the VR scene	The clinician reproduces the setting of the identified situation (e.g. the corridor of the classroom where my boyfriend teased me) using one of the different scenes available in the free NeuroVR software (http://www.neurovr2.org),
Phase 3: Allocentric Experience of the VR scene	The patient is asked to reexperience the event in VR from a first person perspective (the patient does not see his/her body in the scene) expressing and discussing his/her feelings. 
	The patient is then asked what was needed to happen change the feelings in a positive direction. The questions asked follow the Socratic approach, for example "What would need to happen for you to feel better? How does it look through the eyes of a third person? Is there anything you as a third person like to do? How do the other people respond?"
	The main cognitive techniques used in this phase, if needed, are: *Countering*: Once a list of distorted perceptions and cognitions is developed, the process of countering these thoughts and beliefs begins. In countering, the patient is taught to recognize the error in thinking, and substitute more appropriate perceptions and interpretations.
	Label Shifting: The patient first tries to identify the kinds of negative words she uses to interpret situations in her life, such as bad, terrible, obese, inferior, and hateful. The situations in which these labels are used are then listed. The patient and therapist replace each emotional label with two or more descriptive words.

(continued)

Table 7.2 (continued)

Phase 4: Egocentric Experience of the VR scene	The patient is asked to reexperience the event in VR from a third person perspective (the patient sees his/her body in the scene) intervening both to calm and reassuring his/her virtual avatar and to counter any negative evaluation. 
	The main cognitive techniques used in this phase, if needed, are: *Alternative Interpretation*: The patient learns to stop and consider other interpretations of a situation before proceeding to the decision-making stage. The patient develops a list of problem situations, evoked emotions, and interpretative beliefs. The therapist and patient discuss each interpretation and if possible identify the kind of objective data that would confirm one of them as correct.
	Deactivating the Illness Belief: The therapist first helps the client list her beliefs concerning weight and eating. The extent to which the illness model influences each belief is identified. The therapist then teaches the client a cognitive/behavioral approach to interpreting maladaptive eating behaviors and shows they can be understood from this framework.

In 2001, Riva and colleagues divided 28 obese women into two equal groups in order to compare the results obtained from the application of two different treatments: one based on ECT and another on the psycho-nutritional intervention of traditional cognitive-behavioral treatment (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 over-eating and reported anxiety. A later study by the same team (Riva et al. 2002) 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 as regards the reduction of binge eating behavior.

A year later Riva et al. (2003) 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 six-month

follow-up 77% of people in the ECT group had stopped bingeing, compared with 56% and 22% in the CBT and nutritional psychoeducation groups, respectively. In 2006, Riva provided new evidence for the efficacy of ECT in the treatment of obesity (Riva et al. 2006). On this occasion the sample comprised 211 obese women (aged 18–50 and 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 six-month and twelve-month follow-up (Riva et al. 2012).

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 situation, which, in addition to allowing the body image disturbance to be treated, increases the user's sense of self-efficacy.

In a further study Cesa et al. (2013) 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 who received the nutritional psychoeducation alone, while both ECT and CBT were successful in maintaining a low rate of monthly binge eating episodes. In a final study (Gutiérrez-Maldonado et al. 2016b) 163 female morbidly obese inpatients (body mass index >40) were randomly assigned to three conditions: a standard behavioral inpatient program (SBP), SBP plus standard CBT, and ECT. Patients' weight, eating behavior, and body dissatisfaction were measured at the start and upon completion of the inpatient program. Weight was assessed also at one-year follow-up. All measures improved significantly at discharge from the inpatient program, and no significant difference was found among the conditions. However, odds ratios showed that patients in the ECT condition had a greater probability of maintaining or improving weight loss at one-year follow-up than SBP patients had (48% vs. 11%, $p = 0.004$) and, to a lesser extent, than CBT patients had (48% vs. 29%, $p = 0.08$). Indeed, only ECT was effective in further improving weight loss at one-year follow-up. On the contrary, participants who received only the inpatient program regained back, on average, most of the weight they had lost. Findings support the hypothesis that a VR module addressing the locked negative memory of the body may enhance the long-term efficacy of standard CBT.

Perpiñá et al. (1999), developed another application for the treatment of ED that was tested in a controlled study with a clinical sample (patients with AN and BN). With this objective, the researchers combined three treatment components:

- An adaptation of the body image disturbance treatment of Cash (1996) and Rosen (1997), consisting of psychoeducation, exposure, intervention on safety behaviors, cognitive restructuring and self-esteem related to the body. This cognitive-behavioral programme was developed for eight weekly group sessions of 3 h each.
- A VR component, applied in parallel to the body image treatment over six, weekly individual sessions of 1 h each.
- A relaxation component, again implemented in parallel to the treatment for body image disturbances over six, weekly individual sessions of 1 h each. This final component was added in order 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 ED (anorexia nervosa or bulimia nervosa) were randomly assigned to two treatment conditions: the VR condition (cognitive-behavioral treatment + VR) and the standard treatment for body image disturbances (cognitive-behavioral treatment + relaxation). Thirteen of the eighteen 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 towards 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 an increased motivation and adherence to treatment.

These results show that greater improvement was achieved with the addition of the VR component compared to 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 twelve patients (seven with AN and five with BN). The results showed that the improvement achieved after completing the treatment was not only maintained after 12 months but actually increased (Perpiñá et al. 2004). Similarly, a case study by the same authors (Perpiñá et al. 2001) also reported an improvement in the ED patient's symptomatology at one-year follow-up. Salorio del Moral and colleagues (Salorio del Moral et al. 2004) published another case study in which they applied a ten-session treatment programme 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 one-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.

In a further study, Marco et al. (2013) integrated this VR body image protocol within a Cognitive Behavioral Treatment (CBT) for eating disorders and compared it with the CBT alone in a sample of 34 ED patients. Results showed that the patients

who received the VR component improved more than the group without this component. Furthermore, improvement was maintained in post-treatment and at one-year follow-up.

Perpiñá and colleagues (Perpiñá et al. 2001) conducted a study with a small sample of ED patients (five with BN and four with 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 were 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. Secondly, 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 re-create situations but also to help patients cope with mental representations of their fears.

Virtual reality technology has been also used to increase adherence to physical activity in obese individuals. Ruiz and colleagues (Ruiz et al. 2012) exposed 30 overweight and obese participant 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.

Virtual Reality in the Treatment of Binge Eating-Related Disorders

Cognitive-behavioral therapy (CBT) is considered the treatment of choice for both BN and BED (Wilson et al. 2007) and was given the highest rating in the National Institute of Mental Health (2004) review of evidence-based treatments. However, an important percentage of BN and BED patients fail to respond by the end of the treatment and the effects tend to wane in the long term (Amianto et al. 2015; Berkman et al. 2007; Lampard and Sharbanee 2015; Wilson et al. 2010). Consequently, the addition of second-level treatment has been proposed in those cases where the first level (i.e., CBT) does not work (Wilson et al. 2007). Although there is some evidence that BN and BED patients who do not stop binge eating after CBT benefit from additional CBT sessions focusing on the specific problem areas identified at the end of the initial program (Eldredge et al. 1997), it has been suggested that second-level interventions targeting specific features associated with poor response may represent a better option (Dakanalis et al. 2016; Dakanalis et al. 2017; Halmi 2013).

In line with this approach, Gutiérrez-Maldonado and colleagues created a new treatment method based on cue exposure via virtual reality (Ferrer-Garcia et al. 2017a, b; Gutiérrez-Maldonado et al. 2016a, b; Pla-Sanjuanelo et al. 2007). The novelty of this proposal was the addition of VR to cue-exposure procedures, which have proved effective for the treatment of binge-related eating disorders in previous research (see Gutiérrez-Maldonado et al. 2013; and Koskina et al. 2013 for a review). This addition aims to increase the efficacy of cue exposure therapy (CET) by enhancing its ecological validity, while reducing the logistic complications associated with exposure to real cues (i.e. food).

Cue exposure therapy is based on classic conditioning theory. According to this model, the intake of food is considered the unconditioned stimulus and all stimuli associated with this action (e.g., the presence of palatable food, emotional states, the smell of food) are considered the conditioned stimuli. Once conditioning has been established, the presence of conditioned stimuli (e.g., sweets) elicits physiological responses (experienced as food craving) which in turn trigger binge episodes (Jansen et al. 1989; Jansen 1998). The main objective of CET is to extinguish food craving by breaking the bond between the conditioned stimuli and the food craving. Toro and Martínez-Mallén (Martínez-Mallén et al. 2007; Toro et al. 2003) proposed an alternative explanation of the CET rationale. According to them, anxiety, stress and negative mood are strongly associated with binge behavior. Episodes of excess intake at the onset of the disorder generate feelings of anxiety, shame and guilt. With time, exposure to cues related with binges produce anticipatory anxiety in BN and BED patients and it is this anxiety that leads to "bulimic hunger" (Martínez-Mallén et al. 2007). These two explanations are not mutually exclusive; in fact, BN and BED patients frequently report experiencing food craving associated with high levels of anxiety and negative mood (Pla-Sanjuanelo et al. 2015). As Martínez-Mallén et al. (2007) suggested, anxiety and food craving are experienced simultaneously in the presence of binge-related cues.

Although CET is considered an effective intervention for BN and BED (especially in cases in which CBT does not achieve good results; indeed, it has been proposed as a second line of treatment in these situations, Koskina et al. 2013), logistical difficulties and the time necessary for in vivo CET to work have hindered its development and implementation (Gutiérrez-Maldonado et al. 2013). To overcome these difficulties, Gutiérrez-Maldonado proposed using VR-based exposure for CET. VR technology has several benefits for exposure therapy: first, VR environments maintain good ecological validity even when exposure is conducted in the therapist's office and are therefore easy to generalize to real situations. Second, VR exposure allows the therapist to control all the parameters of the situation and to adapt the exposure environment to the specific needs of each patient at each stage of treatment. Third, using VR scenarios patients can be exposed not only to specific stimuli but to contextual cues related with the problem.

Gutiérrez-Maldonado and colleagues found that exposure to VR environments incorporating both specific stimuli (e.g., high calorie food) and contextual cues (e.g., kitchen) significantly reduces food craving and anxiety (Gutiérrez-Maldonado et al. 2016a, b; Pla-Sanjuanelo et al. 2016) in a non-clinical sample. Likewise, a

case study showed that six sessions of VR-based CET were sufficient to extinguish episodes of binge-eating, and associated purging behaviors, in a BN patient who initially failed to successfully respond to CBT (Pla-Sanjuanelo et al. 2016).

On the basis of these results, a multicenter, randomized, parallel-group study was conducted at different hospitals (five sites) in three European cities in order to establish whether the addition of a six-session VR-CET second-level treatment, after a structured CBT program, achieved a better outcome than adding six more CBT sessions (A-CBT) in treatment-resistant patients aged over 18 with BN and BED (https://clinicaltrials.gov/ct2/show/NCT02237300). Exclusion criteria were suicidal ideation and severe mental disorder (psychosis or dementia). Sixty-four patients (35 BN and 29 BED) were randomly assigned to two experimental conditions: VR-CET and A-CBT. Frequency of binge and purge episodes, drive for thinness, bulimia symptoms, body dissatisfaction, food craving and anxiety were assessed both before starting second-level treatment and once it had finished.

Even though patients in both groups improved, VR-CET was significantly superior to A-CBT at the end of second-level treatment in terms of the proportion of participants who achieved abstinence from binge eating episodes: 17/32 (53%) of those treated with VR-CET, compared with 8/32 (25%) of those treated with A-CBT ($N = 32$) ($\chi^2 = 5.32$, $p = .02$). Amongst BN patients, VR-CET was also superior to A-CBT at the end of second-level treatment in terms of the percentage of participants that achieved abstinence from purging episodes (75% vs. 31%, [$\chi^2 = 6.56$, $p = 0.02$]). Consistent with these results, the VR-CET group showed a lower clinician-rated frequency of binge and purge episodes and a lower self-reported tendency to engage in episodes of uncontrollable overeating (assessed by the bulimia scale on the EDI-3) than the A-CBT group at the end of second-level treatment, although there were no significant differences between groups at the pre-randomization/pre-test phase (Ferrer-Garcia et al. 2017a). Furthermore, good outcomes were maintained at 6-month follow-up. The authors conclude that the results highlighted the superiority of VR-CET over A-CBT. This software can be downloaded for free at http://www.ub.edu/vrpsylab/foodcraving/

Conclusions

During the last decade virtual reality (VR) emerged as a technology that is especially suitable for the study, assessment and treatment of weight related disorders (Riva 2017; Riva et al. 2016a, b; Wiederhold et al. 2016). Taking into account the results obtained to date in the studies reviewed, several conclusions can be drawn (Gutiérrez-Maldonado et al. 2016a, b). Even if It has been recognized that the field had in the past very few methodologically strong studies, the situation is quite different now. Three different randomized, controlled trials (Cesa et al. 2013; G.M. Manzoni et al. 2016; Marco et al. 2013) have shown at one-year follow-up that VR had a higher efficacy than the gold standard in the field, i.e., cognitive behavioral therapy (CBT).

More, this chapter also outlined the potential of virtual reality in the study of weight-related disorders. This approach is currently used for the assessment of body image distortions, emotional responses and social comparison skills in clinical and subclinical subjects.

First, VR can be used to improve our knowledge about the body image concept. For example, different studies explored whether perceptual distortions in body image and body dissatisfaction changed depending on the situation.

Second, VR can be used to evaluate the emotional responses produced by food exposure. In fact, real food and VR food produce comparable emotional reactions – anxiety, food craving, impulse to over-eat, and guilt feelings – in ED patients and this reaction was stronger than the one produced by photographs of food.

Third, it is also possible to use the potential of virtual reality (VR) to elicit social comparison tendencies induced by subjects with different weight and body sizes. The available studies suggest that more negative stereotyping and less visual contact are produced by the interaction with overweight/obese subjects.

In conclusion, VR is a powerful tool for studying, assessing and treating weight related disorders. Nevertheless, future research and clinical practice are still required for transforming virtual reality in a real tool for researchers and clinicians.

References

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

Amianto, F., Ottone, L., Abbate Daga, G., & Fassino, S. (2015). Binge-eating disorder diagnosis and treatment: A recap in front of DSM-5. *BMC Psychiatry, 15*, 70–76.

Baars, B. (1988). *A cognitive theory of consciousness*. New York: Cambridge University Press.

Berkman, N. D., Lohr, K. N., & Bulik, C. M. (2007). Outcomes of eating disorders. A systematic review of the literature. *International Journal of Eating Disorder, 40*, 293–309.

Blechert, J., Ansorge, U., Beckmann, S., & Tuschen-Caffier, B. (2011). The undue influence of shape and weight on self-evaluation in anorexia nervosa, bulimia nervosa and restrained eaters: a combined ERP and behavioral study. *Psychological Medicine, 41*(1), 185–194. https://doi.org/10.1017/S0033291710000395.

Butters, J. W., & Cash, T. F. (1987). Cognitive-behavioural treatment of women's body-image dissatisfaction. *Journal of Consulting and Clinical Psychology, 55*, 889–897.

Calogero, R. M. (2012). Objectification theory, self-objectification, and body image. In T. F. Cash (Ed.), *Encyclopedia of body image and human appearance* (Vol. 2, pp. 574–580). San Diego: Academic.

Calogero, R. M., Tantleff-Dunn, S., & Thompson, J. K. (2010). *Self-Objectification in women: causes, consequences, and counteractions*. Washington, DC: American Psychological Association.

Cash, T. F. (1996). The treatment of body image disturbances. In J. K. Thompson (Ed.), *Body image, eating disorders and obesity* (pp. 83–107). Washington, DC: APA – American Psychological Association.

Cash, T. F., & Pruzinski, T. (Eds.). (2004). *Body image: A handbook of theory, reasearch & clinical practice*. New York: The Guilford Press.

Cash, T. F., Fleming, E. C., Alindogan, J., Steadman, L., & Whitehead, A. (2002). Beyond body image as a trait: The development and validation of the Body Image States Scale. *Eating Disorders: The Journal of Treatment & Prevention, 10*, 103–113.

Cesa, G. L., Manzoni, G. M., Bacchetta, M., Castelnuovo, G., Conti, S., Gaggioli, A., Mantovani, F., Molinari, E., Cardenas-Lopez, G., & Riva, G. (2013). 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, 15*(6), e113. https://doi.org/10.2196/jmir.2441.

Dakanalis, A., & Riva, G. (2013). Mass media, body image and eating disturbances: The underline mechanism through the lens of the objectification theory. In J. Latzer, J. Merrick, & D. Stein (Eds.), *Body image: Gender differences, sociocultural influences and health implication* (pp. 217–236). New York: Nova Science.

Dakanalis, A., Di Mattei, V. E., Bagliacca, E. P., Prunas, A., Sarno, L., Riva, G., & Zanetti, M. A. (2012). Disordered eating behaviors among Italian men: Objectifying media and sexual orientation differences. *Eating Disorders, 20*(5), 356–367. https://doi.org/10.1080/10640266.2012.715514.

Dakanalis, A., Clerici, M., Di Mattei, V. E., Caslini, M., Favagrossa, L., Bagliacca, E. P., et al. (2013a). Internalization of sociocultural standards of beauty and eating disordered behaviours: The role of body surveillance, shame, and social anxiety. *Journal of Psychopatology, 20*, 33–37.

Dakanalis, A., Zanetti, M. A., Riva, G., & Clerici, M. (2013b). Psychosocial moderators of the relationship between body dissatisfaction and symptoms of eating disorders: A look at a sample of young Italian women. *European Review of Applied Psychology-Revue/Europeenne De Psychologie Appliquee, 63*(5), 323–334. https://doi.org/10.1016/j.erap.2013.08.001.

Dakanalis, A., Gaudio, S., Serino, S., Clerici, M., Carrà, G., & Riva, G. (2016). Body-image distortion in anorexia nervosa. *Nature Reviews Disease Primers, 2*, 16026. https://doi.org/10.1038/nrdp.2016.26.

Dakanalis, A., Colmegna, F., Riva, G., & Clerici, M. (2017). Validity and utility of the DSM-5 severity specifier for binge eating disorder. *International Journal of Eating Disorders, 50*(8), 917–923. https://doi.org/10.1002/eat.22696.

Dakanalis, A., Carrà, G., Calogero, R., Fida, R., Clerici, M., Zanetti, M. A., & Riva, G. (2015). The developmental effects of media-ideal internalization and self-objectification processes on adolescents' negative body-feelings, dietary restraint, and binge eating. *European Child & Adolescent Psychiatry, 24*(8), 997–1010.

Dakanalis, A., Clerici, M., Bartoli, F., Caslini, M., Crocamo, C., Riva, G., & Carrà, G. (2017). Risk and maintenance factors for young women's DSM-5 eating disorders. *Archives of women's mental health, 20*(6), 721–731.

Eldredge, K. L., Agras, W. S., Arnow, B., Telch, C. F., Bell, S., Castonguay, L., & Marnell, M. (1997). The effects of extending cognitive-behavioral therapy for binge eating disorder among initial treatment nonresponders. *International Journal of Eating Disorders, 21*(4), 347–352.

Etu, S. F., & Gray, J. J. (2010). A preliminary investigation of the relationship between induced rumination and state body image dissatisfaction and anxiety. *Body Image, 7*, 82–85.

Ferrer-Garcia, M., & Gutierrez-Maldonado, J. (2012). The use of virtual reality in the study, assessment, and treatment of body image in eating disorders and nonclinical samples: A review of the literature. *Body Image, 9*(1), 1–11. doi: S1740–1445(11)00140–9 [pii].

Ferrer-Garcia, M., Gutiérrez-Maldonado, J., Caqueo-Urízar, A., & Moreno, E. (2009). The validity of virtual environments for eliciting emotional responses in patients with eating disorders and in controls. *Behavior Modification, 3*, 830–854.

Ferrer-Garcia, M., Gutierrez-Maldonado, J., & Pla, J. (2013a). Cue-elicited anxiety and craving for food using virtual reality scenarios. *Studies of Health Technology and Informatics, 191*, 105–109.

Ferrer-Garcia, M., Gutiérrez-Maldonado, J., & Riva, G. (2013b). Virtual reality based treatments in eating disorders and obesity: A review. *Journal of Contemporary Psychology, 43*(4), 207–221. https://doi.org/10.1007/s10879-013-9240-1.

Ferrer-Garcia, M., Gutiérrez-Maldonado, J., Pla-Sanjuanelo, J., Vilalta-Abella, F., Andreu-Gracia, A., Dakanalis, A., Fernandez-Aranda, F., Fusté-Escolano, A., Ribas-Sabaté, J., Riva, G., Saldaña, C., & Sánchez, I. (2015a). External eating as a predictor of cue-reactivity to food-related virtual environments. *Studies in Health Technology and Informatics, 13*(219), 117–122.

Ferrer-Garcia, M., Gutiérrez-Maldonado, J., Treasure, J., & Vilalta-Abella, F. (2015b). Craving for food in virtual reality scenarios in non-clinical sample: Analysis of its relationship with body mass index and eating disorder symptoms. *European Eating Disorders Review, 23*(5), 371–378.

Ferrer-Garcia, M., Gutiérrez-Maldonado, J., Pla-Sanjuanelo, J., Vilalta-Abella, F., Riva, G., Clerici, M., et al. (2017a). A randomised controlled comparison of second-level treatment approaches for treatment-resistant adults with bulimia nervosa and binge-eating disorder: assessing the benefits of virtual reality cue exposure therapy. *European Eating Disorders Review., 25*(6), 479–490. https://doi.org/10.1002/erv.2538. Epub ahead of print.

Ferrer-Garcia, M., Pla-Sanjuanelo, J., Dakanalis, A., Vilalta-Abella, F., Riva, G., Fernández-Aranda, F., et al. (2017b). Eating behavior style predicts craving and anxiety experienced in food-related virtual environments by patients with eating disorders and healthy controls. *Appetite, 117*, 284–293.

Fett, A. K., Lattimore, P., Roefs, A., Geschwind, N., & Jansen, A. (2009). Food cue exposure and body image satisfaction: The moderating role of BMI and dietary restraint. *Body Image, 6*, 14–18.

Fitzsimmons, E. E., & Bardone-Cone, A. M. (2011). Downward spirals of body surveillance and weight/shape concern among African American and Caucasian college women. *Body Image, 8*(3), 216–223. https://doi.org/10.1016/J.Bodyim.2011.04.003.

Fredrickson, B. L., & Roberts, T. (1997). Objectification theory: Toward understanding women's lived experiences and mental health risks. *Psychology of women quarterly, 21*, 173–206.

Gaudio, S., & Riva, G. (2013). Body image disturbances in Anorexia: The link between functional connectivity alterations and reference frames. *Biological Psychiatry, 73*(9), e25–e26. https://doi.org/10.1016/j.biopsych.2012.08.028.

Goldfein, J. A., Walsh, B. T., & Midlarsky, E. (2000). Influence of shape and weight on self-evaluation in bulimia nervosa. *International Journal of Eating Disorders, 27*(4), 435–445. https://doi.org/10.1002/(Sici)1098-108x(200005)27:4<435::Aid-Eat8>3.0.Co;2–2.

Gorini, A., Griez, E., Petrova, A., & Riva, G. (2010). Assessment of emotional responses produced to real food, virtual food and photographs of food in patients affected by eating disorders. *Annals of General Psychiatry, 9*, 30.

Guitard, T., Aimé, M., Bouchard, S., Loranger, C., & Cotton, K. (2011). Body dissatisfaction: eliciting emotions by social comparison in a virtual bar. *Journal of CyberTherapy and Rehabilitation, 4*(2), 295–297.

Gutiérrez-Maldonado, J., Ferrer-Garcia, M., Caqueo-Urízar, A., & Letosa-Porta, A. (2006). Assessment of emotional reactivity produced by exposure to virtual environments in patients with eating disorders. *CyberPsychology & Behavior, 9*(5), 507–513.

Gutiérrez-Maldonado, J., Ferrer-Garcia, M., Caqueo-Urízar, A., & Moreno, E. (2010). Body image in eating disorders: The influence of exposure to virtual environments. *CyberPsychology & Behavior, 13*, 521–531.

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

Gutiérrez-Maldonado, J., Pla-Sanjuanelo, J., & Ferrer-Garcia, M. (2016a). Cue-exposure software for the treatment of bulimia nervosa and binge eating disorder. *Psicothema, 28*(4), 363–369.

Gutiérrez-Maldonado, J., Wiederhold, B. K., & Riva, G. (2016b). Future directions: How virtual reality can further improve the assessment and treatment of eating disorders and obesity. *Cyberpsychology, Behavior & Social Networking, 19*(2), 148–153.

Haines, J., & Neumark-Sztainer, D. (2006). Prevention of obesity and eating disorders: A consideration of shared risk factors. *Health Education Research, 21*(6), 770–782.

Halmi. (2013). Perplexities of treatment resistance in eating disorders. *BCM Psychiatry, 13*, 292. http://www.biomedcentral.com/1471-244X/13/292.

Head, H. (1926). *Aphasia and kindred disorders of speech*. Cambridge: Cambridge University Press.

Jansen, A. (1998). A learning model of binge eating: Cue reactivity and cue exposure. *Behaviour Reasearch and Therapy, 36*, 257–272.

Jansen, A., Van Den Hout, M. A., De Loof, C., Zandbergen, J., & Griez, E. (1989). A case of bulimia successfully treated by cue exposure. *Journal of Behavior Therapy and Experimental Psychiatry, 20*(4), 327–332. https://doi.org/10.1016/0005-7916(89)90064-5.

Johnston, J. M. (2004). Eating disorders and childhood obesity: Who are the real gluttons? *MAJ, 171*(12), 1459–1460. https://doi.org/10.1503/cmaj.1041111.

Keizer, A., van Elburg, A., Helms, R., & Dijkerman, H. C. (2016). A virtual reality full body illusion improves body image disturbance in Anorexia Nervosa. *PLoS One, 11*(10), e0163921. https://doi.org/10.1371/journal.pone.0163921.

Kim, D. S. (2009). Body image dissatisfaction as an important contributor to suicidal ideation in Korean adolescents: Gender difference and mediation of parent and peer relationships. *Journal of Psychosomatic Research, 66*(4), 297–303. https://doi.org/10.1016/j.jpsychores.2008.08.005.

Koskina, A., Campbell, I. C., & Schmidt, U. (2013). Exposure therapy in eating disorders revisited. *Neuroscience & Biobehavioral Reviews, 37*(2), 193–208. https://doi.org/10.1016/j.neubiorev.2012.11.010.

Kostanski, M., & Gullone, E. (1999). Dieting and body image in the child's world: Conceptualization and behavior. *The Journal of Genetic Psychology, 160*(4), 488–499. https://doi.org/10.1080/00221329909595561.

Lampard, A. M., & Sharbanee, J. M. (2015). The cognitive-behavioural theory and treatment of bulimia nervosa: An examination of treatment mechanisms and future directions. *Australian Psychologist, 50*, 6–13.

Lattimore, P., & Hutchinson, R. (2010). Perceived calorie intake and state body-image satisfaction in women attempting weight loss: A preliminary investigation. *Body Image, 7*, 15–21.

Ledoux, T., Nguyen, A. S., Bakos-Block, C., & Bordnick, P. (2013). Using virtual reality to study food cravings. *Appetite, 71*, 396–402. https://doi.org/10.1016/j.appet.2013.09.006.

Lee, S. (1995). Weight phobia versus fat phobia in anorexia nervosa. *Transcultural Psychiatric Research Review, 32*, 439–440.

Makinen, M., Puukko-Viertomies, L. R., Lindberg, N., Siimes, M. A., & Aalberg, V. (2012). Body dissatisfaction and body mass in girls and boys transitioning from early to mid-adolescence: Additional role of self-esteem and eating habits. *BMC psychiatry, 12*, 35. https://doi.org/10.1186/1471-244X-12-35.

Manzoni, G. M., Cesa, G. L., Bacchetta, M., Castelnuovo, G., Conti, S., Gaggioli, A., et al. (2016). Virtual reality-enhanced cognitive-behavioral therapy for morbid obesity: A randomized controlled study with 1 year follow-up. *Cyberpsychology, Behavior, and Social Networking, 19*(2), 134–140. https://doi.org/10.1089/cyber.2015.0208.

Marco, J. H., Perpina, C., & Botella, C. (2013). Effectiveness of cognitive behavioral therapy supported by virtual reality in the treatment of body image in eating disorders: One-year follow-up. *Psychiatry Research, 209*(3), 619–625. https://doi.org/10.1016/j.psychres.2013.02.023.

Martínez-Mallén, E., Castro-Fornieles, J., Lázaro, L., Moreno, E., Morer, A., Font, E., et al. (2007). Cue exposure in the treatment of resistant adolescent bulimia nervosa. *International Journal of Eating Disorders, 40*(7), 596–601. https://doi.org/10.1002/eat.20423.

Menzel, J. E., Schaefer, L. M., Burke, N. L., Mayhew, L. L., Brannick, M. T., & Thompson, J. K. (2010). Appearance-related teasing, body dissatisfaction, and disordered eating: A meta-analysis. *Body Image, 7*(4), 261–270. https://doi.org/10.1016/j.bodyim.2010.05.004.

Monro, F. J., & Huon, G. F. (2006). Media-portrayed idealized images, self-objectification, and eating behavior. *Eating Behaviors, 7*(4), 375–383. https://doi.org/10.1016/j.eatbeh.2005.12.003.

Myers, P. N., & Biocca, F. A. (1992). The elastic body image: The effect of television advertisement and programming on body image distortions in young women. *Journal of Communication, 42*, 108–133.

National Institute for Clinical Excellence. (2004). *Eating disorders: Core interventions in the treatment and management of anorexia nervosa, bulimia nervosa, related eating disorders* (NICE Clinical Guideline No. 9). London, England: Author.

Neumark-Sztainer, D. (2009). Preventing obesity and eating disorders in adolescents: What can health care providers do. *Journal of Adolescent Health, 44*(3), 206–213. doi: S1054-139X(08)00663–0 [pii]10.1016/j.jadohealth.2008.11.005.

Neumark-Sztainer, D., Wall, M., Guo, J., Story, M., Haines, J., & Eisenberg, M. (2006). Obesity, disordered eating, and eating disorders in a longitudinal study of adolescents: How do dieters fare 5 years later. *Journal of the American Dietetic Association, 106*(4), 559–568. S0002–8223(06)00004–6 [pii]. https://doi.org/10.1016/j.jada.2006.01.003.

Ogden, C. L., Carroll, M. D., & Flegal, K. M. (2008). High body mass index for age among US children and adolescents, 2003–2006. *Jama-Journal of the American Medical Association, 299*(20), 2401–2405. https://doi.org/10.1001/Jama.299.20.2401.

Pérez, B., Gutiérrez-Maldonado, J., & Ferrer-Garcia, M. (2004). Cuestionario de Depresión Barcelona: evaluación del curso de la depresión. In *VII European conference on psychological assessment*. Spain., April: Málaga.

Perpiñá, C., Botella, C., Baños, R. M., Marco, H., Alcañiz, M., & Quero, S. (1999). Body image and virtual reality in eating disorders: Is exposure to virtual reality more effective than the classical body image treatment? *CyberPsychology and Behavior, 2*, 149–159.

Perpiñá, C., Botella, C., & Baños, R. M. (2000). *Imagen corporal en los trastornos alimentarios. evaluación y tratamiento mediante realidad virtual*. Valencia: Promolibro.

Perpiñá, C., Baños, R., Botella, C., & Marco, J. H. (2001). Virtual reality as a therapy tool: A case study on body image alteration disorders. *Revista Argentina de Clínica Psicológica, 10*, 227–241.

Perpiñá, C., Marco, J. H., Botella, C., & Baños, R. (2004). 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, 12*, 519–537.

Perpiñá, C., Roncero, M., Fernández-Aranda, F., Jiménez-Murcia, S., Forcano, L., & Sánchez, I. (2013). Clinical validation of a virtual environment for normalizing eating patterns in eating disorders. *Comprehensive Psychiatry, 54*(6), 680–686.

Pinto-Gouveia, J., & Matos, M. (2011). Can shame memories become a key to identity? The centrality of shame memories predicts psychopathology. *Applied Cognitive Psychology, 25*, 281–290. https://doi.org/10.1002/acp.1689.

Pla-Sanjuanelo, J., Ferrer-Garcia, M., Gutierrez-Maldonado, J., Riva, G., Andreu-Gracia, A., Dakanalis, A., et al. (2015). Identifying specific cues and contexts related to bingeing behavior for the development of effective virtual environments. *Appetite, 87*, 81–89. https://doi.org/10.1016/j.appet.2014.12.098.

Pla-Sanjuanelo, J., Ferrer-Garcia, M., Vilalta-Abella, F., Gutierrez-Maldonado, J., Andreu-Gracia, A., Dakanalis, A., Escandón-Nagel, N., Fernandez-Aranda, F., Gomez-Tricio, O., Ribas-Sabaté, J., Riva, G., Sánchez, T., & Tena, V. (2016). Using virtual reality for cue-exposure therapy in a case of bulimia nervosa. In *Annual review of CyberTherapy and telemedicine: A decade of virtual reality* (Vol. 14, pp. 155–160).

Pla-Sanjuanelo, J., Ferrer-Garcia, M., Vilalta-Abella, F., Riva, G., Dakanalis, A., Ribas-Sabaté, J., et al. (2017). Testing virtual reality-based cue-exposure software: Which cue-elicited responses best discriminate between patients with eating disorders and healthy controls? *Eating and Weight Disorders-Studies on Anorexia Bulimia and Obesity*. https://doi.org/10.1007/s40519-017-0419-4. Epub ahead of print.

Riva, G. (1998a). Virtual reality in psychological assessment: The body image virtual reality scale. *CyberPsychology and Behavior, 1*, 37–44.

Riva, G. (1998b). Modifications of body-image induced by virtual reality. *Perceptual and Motor Skills, 86*, 163–170.

Riva, G. (1998c). Virtual environment for body image modification: Virtual reality system for treatment of body image disturbances. *Computers in Human Behavior, 14*, 477–490.

Riva, G. (2003). Virtual environments in clinical psychology. *Psychotherapy: Theory, Research, Practice and Training, 40*, 68–76.

Riva, G. (2005). Virtual reality in psychotherapy: Review. *Cyberpsychology & Behavior, 8*(3), 220–230. discussion 231-240.

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

Riva, G. (2011). The key to unlocking the virtual body: Virtual reality in the treatment of obesity and eating disorders. *Journal of Diabetes Science and Technology, 5*(2), 283–292.

Riva, G. (2012). Neuroscience and eating disorders: The allocentric lock hypothesis. *Medical Hypotheses, 78*, 254–257. S0306-9877(11)00566-4 [pii] 10.1016/j.mehy.2011.10.039.

Riva, G. (2014). Out of my real body: Cognitive neuroscience meets eating disorders. *Frontiers in Human Neuroscience, 8*, 236. https://doi.org/10.3389/fnhum.2014.00236.

Riva, G. (2017). Letter to the editor: Virtual reality in the treatment of eating and weight disorders. *Psychological Medicine, 47*(14), 2567–2568. https://doi.org/10.1017/S0033291717001441.

Riva, G. (2018). The neuroscience of body memory: From the self through the space to the others. *Cortex, 104*, 241–260.

Riva, G., & Gaudio, S. (2012). Allocentric lock in anorexia nervosa: New evidences from neuroimaging studies. *Medical Hypotheses, 79*(1), 113–117. https://doi.org/10.1016/j.mehy.2012.03.036.

Riva, G., & Gaudio, S. (2018). Locked to a wrong body: eating disorders as the outcome of a primary disturbance in multisensory body integration. *Consciousness and cognition, 59*, 57–59.

Riva, G., & Melis. (1997a). Virtual reality for the treatment of body image disturbances. In G. Riva (Ed.), *Virtual reality in neuro-psycho-physiology: Cognitive, clinical and methodological issues in the assessment and rehabilitation* (pp. 95–111). Amsterdam: IOS Press.

Riva, G., & Melis. (1997b). Virtual reality for the treatment of body image disturbances. *Studies in Health Technology and Informatics, 44*, 95–111.

Riva, G., Melis, L., & Bolzoni, M. (1997). Treating body image disturbances. *Communications of the ACM, 40*, 69–71.

Riva, G., Bacchetta, M., Baruffi, M., Rinaldi, S., & Molinari, E. (1998a). Experiential cognitive therapy: A VR based approach for the assessment and treatment of eating disorders. In G. Riva, B. K. Wiederhold, et al. (Eds.), *Virtual environments in clinical psychology and neuroscience: Method and techniques in advanced patient-therapist interaction* (pp. 120–135). Amsterdam: IOS Press.

Riva, G., Bacchetta, M., Baruffi, M., Rinaldi, S., & Molinari, E. (1998b). Experiential cognitive therapy in anorexia nervosa. *Eating and Weight Disorders, 3*, 141–150.

Riva, G., Bacchetta, M., Baruffi, M., Defrance, C., Gatti, F., Galimberti, C., et al. (1999). VREPAR 2: VR in eating disorders. *Cyberpsychology & Behavior, 2*, 77–79.

Riva, G., Bacchetta, M., Baruffi, M., Cirillo, G., & Molinari, E. (2000a). Virtual reality environment for body image modification: A multidimensional therapy for the treatment of body image in obesity and related pathologies. *Cyberpsychology & Behavior, 3*, 421–431.

Riva, G., Bacchetta, M., Baruffi, M., Rinaldi, S., Vincelli, F., & Molinari, E. (2000b). Realtà virtual e trattamento dei disturbi del comportamento alimentare. *Psicoterapia Cognitiva e Comportamentale, 6*, 173–184.

Riva, G., Marchi, S., & Molinari, E. (2000c). Body image and eating restraint: A structural modeling analysis. *Eating and Weight Disorders, 5*(1), 38–42.

Riva, G., Bachetta, M., Baruffi, M., & Molinari, E. (2001). Virtual reality-based multidimensional therapy for the treatment of body image disturbances in obesity: A controlled study. *Cyberpsychology & Behavior, 4*, 511–526.

Riva, G., Bachetta, M., Baruffi, M., & Molinari, E. (2002). 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, 6*, 224–234.

Riva, G., Bacchetta, M., Cesa, G., Conti, S., & Molinari, E. (2003). Six-month follow-up of in-patient experiential-cognitive therapy for binge eating disorders. *Cyberpsychology & Behavior, 6*, 251–258.

Riva, G., Bacchetta, M., Cesa, G., Conti, S., Castelnuovo, G., Mantovani, F., & Molinari, E. (2006). Is severe obesity a form of addiction? Rationale, clinical approach, and controlled clinical trial. *CyberPsychology and Behavior, 9*, 457–479.

Riva, G., Gaggioli, A., Villani, D., Preziosa, A., Morganti, F., Corsi, R., Faletti, G., & Vezzadini, L. (2007). NeuroVR: An open source virtual reality platform for clinical psychology and behavioral neurosciences. *Studies in Health Technology and Informatics, 125*, 394–399.

Riva, G., Carelli, L., Gaggioli, A., Gorini, A., Vigna, C., Corsi, R., Faletti, G., & Vezzadini, L. (2009). NeuroVR 1.5 – A free virtual reality platform for the assessment and treatment in clinical psychology and neuroscience. *Studies of Health Technology and Informatics, 142*, 268–270.

Riva, G., Gaggioli, A., Grassi, A., Raspelli, S., Cipresso, P., Pallavicini, F., Vigna, C., Gagliati, A., Gasco, S., & Donvito, G. (2011). NeuroVR 2 – A free virtual reality platform for the assessment and treatment in behavioral health care. *Studies of Health Technology and Informatics, 163*, 493–495.

Riva, G., Castelnuovo, G., Cesa, G., Gaggioli, A., Mantovani, F., & Molinari, E. (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.

Riva, G., Gaudio, S., & Dakanalis, A. (2015). The neuropsychology of self objectification. *European Psychologist, 20*(1), 34–43. https://doi.org/10.1027/1016-9040/a000190.

Riva, G., Baños, R. M., Botella, C., Mantovani, F., & Gaggioli, A. (2016a). Transforming experience: The potential of augmented reality and virtual reality for enhancing personal and clinical change. *Frontiers in Psychiatry, 7*(164). https://doi.org/10.3389/fpsyt.2016.00164.

Riva, G., Gutierrez-Maldonado, J., & Wiederhold, B. K. (2016b). Virtual worlds versus real body: Virtual reality meets eating and weight disorders. *Cyberpsychology, Behavior and Social Networking, 19*(2), 63–66. https://doi.org/10.1089/cyber.2016.29025.gri.

Rodin, J., & Larson, L. (1992). Social factors and the ideal body shape. In K. D. Brownell & J. Rodin (Eds.), *Eating, body weight, and performance in athletes: Disorders of modern society* (pp. 146–158). Philadelphia: Lea & Febiger.

Rodin, J., Silberstein, L., & Striegel-Moore, R. (1984). Women and weight: A normative discontent. *Nebraska Symposium on Motivation, 32*, 267–307.

Rorty, M., Yager, J., & Rossotto, E. (1993). 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, 14*, 249–260.

Rosen, J. C. (1997). Cognitive-behavioural body image therapy. In D. M. Garner & P. E. Garfinkel (Eds.), *Handbook of treatment for eating disorders* (pp. 188–201). New York: Guilford Press.

Rosen, J. C., & Ramírez, E. (1998). A comparison of eating disorders and body dysmorphic disorder on body image and psychological adjustment. *Journal of Psychosomatic Research, 44*, 441–449.

Rudiger, J. A., Cash, T. A., Roehrig, M., & Thompson, J. K. (2007). Day-to-day body states: Prospective predictors of intra-individual level of variability. *Body Image, 4*, 1–9.

Ruiz, J. R., Andrade, A. D., Anam, R., Aguiar, R., Sun, H., & Roos, B. A. (2012). 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, 173*, 405–411.

Salorio del Moral, P., Gómez Sánchez, R., Morales Moreno, I., Torres Ortuño, A., Díaz Cuenca, A., & Alegría Capel, A. (2004). La realidad virtual, una nueva herramienta terapéutica. Tratamiento de la imagen corporal en los trastornos alimentarios. *Revista Electrónica Semestral de Enfermería, 5*, 1–17.

Schienle, A., Schäfer, A., Hermann, A., & Vaitl, D. (2009). Binge-eating disorders: Reward sensivity and brain activation to images of food. *Biological Psychiatry, 65*, 654–661.

Serino, S., Pedroli, E., Keizer, A., Triberti, S., Dakanalis, A., Pallavicini, F., et al. (2016a). Virtual reality body swapping: A tool for modifying the Allocentric memory of the body. *Cyberpsychology, Behavior and Social Networking, 19*(2), 127–133. https://doi.org/10.1089/cyber.2015.0229.

Serino, S., Scarpina, F., Keizer, A., Pedroli, E., Dakanalis, A., Castelnuovo, G., et al. (2016b). A novel technique for improving bodily experience in a non-operable super-super obesity case. *Frontiers in Psychology, 7*, 837. https://doi.org/10.3389/fpsyg.2016.00837.

Singh, G. K., Kogan, M. D., Van Dyck, P. C., & Siahpush, M. (2008). Racial/ethnic, socioeconomic, and behavioral determinants of childhood and adolescent obesity in the United States:

Analysing independent and joint associations. *Annals of Epidemiology, 18*(9), 682–695. doi: S1047-2797(08)00112-9 [pii].
Slade, P. D., & Brodie, D. (1994). Body image distortion and eating disorder: A reconceptualitation based on recent literature. *European Eating Disorders Review, 2*(1), 32–46.
Smeets, M. A. M. (1997). The rise and fall of body size estimation research in anorexia nervosa: A review and reconceptualization. *European Eating Disorders Review, 5*, 75–95.
Smolak, L. (2012). Body image development – Girl children. In T. Cash (Ed.), *Encyclopedia of body image and human appearance* (pp. 212–218). Oxford: Academic.
Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Handbook of STAI*. Palo Alto: Consulting Psychologist Press. [Spanish adaptation: Seisdedos, N. (1988). Barcelona: Ediciones TEA.].
Stice, E., Presnell, K., Shaw, H., & Rohde, P. (2005). Psychological and behavioral risk factors for obesity onset in adolescent girls: A prospective study. *Journal of Consulting and Clinical Psychology, 73*(2), 195–202.
Stice, E., Davis, K., Miller, N. P., & Marti, C. N. (2008). Fasting increases risk for onset of binge eating and bulimic pathology: A 5-year prospective study. *Journal of Abnormal Psychology, 117*(4), 941–946. doi: 2008-16252-019 [pii]10.1037/a0013644.
Sweetingham, R., & Waller, G. (2008). Childhood experiences of being bullied and teased in the eating disorders. *European Eating Disorders Review, 16*(5), 401–407.
Thompson, J. K. (Ed.). (1996). *Body image, eating disorders, and obesity: An integrative guide for assessment and treatment*. Washington, DC: American Psychological Association.
Thompson, J. K., Heinberg, L. J., Altabe, M., & Tantleff-Dunn, S. (1999). The scope of body image disturbance: The big picture. In J. K. Thompson, L. J. Heinberg, M. Altabe, & S. Tantleff-Dunn (Eds.), *Exacting beauty: Theory, assessment, and treatment of body image disturbance* (pp. 19–50). Washington, DC: American Psychological Association.
Toro, J., Cervera, M., Feliu, M. H., Garriga, N., Jou, M., Martinez, E., & Toro, E. (2003). Cue exposure in the treatment of resistant bulimia nervosa. *International Journal of Eating Disorders, 34*, 1–8.
van den Berg, P., Paxton, S. J., Keery, H., Wall, M., Guo, J., & Neumark-Sztainer, D. (2007). Body dissatisfaction and body comparison with media images in males and females. *Body Image, 4*(3), 257–268. https://doi.org/10.1016/j.bodyim.2007.04.003.
Van Strien, T., Frijter, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch eating behavior questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International Journal of Eating Disorders, 5*, 295–315.
Van Strien, T., Herman, C. P., & Verheijden, M. W. (2009). Eating style, overeating, and overweight in a representative Dutch sample. Does external eating play a role? *Appetite, 52*, 380–387. https://doi.org/10.1016/j.appet.2008.11.010.
Vandereycken, W. (1990). The relevance of body-image disturbances for the treatment of bulimia. In M. M. Fichter (Ed.), *Bulimia nervosa. Basic research, diagnosis and treatment* (pp. 85–91). Chichester: Wiley.
Vandereycken, W., Probst, M., & Meermann, R. (1988). An experimental video-confrontation procedure as a therapeutic technique and a research tool in the treatment of eating disorders. In K. M. Pirke, W. Vandereycken, & D. Ploog (Eds.), *The psychobiology of bulimia nervosa* (pp. 172–178). Berlin: Springer.
Wiederhold, B. K., Riva, G., & Gutiérrez-Maldonado, J. (2016). Virtual reality in the assessment and treatment of weight-related disorders. *Cyberpsychology, Behavior and Social Networking, 19*(2), 67–73. https://doi.org/10.1089/cyber.2016.0012.
Wilson, G. T., Grilo, C. M., & Vitousek, K. M. (2007). Psychological treatment of eating disorders. *American Psychologist, 62*(3), 199–216.
Wilson, G. T., Wilfley, D. E., Agras, W. S., & Bryson, S. W. (2010). Psychological treatments of binge eating disorder. *Archives of General Psychiatry, 67*, 94–101.
Wooley, S. C., & Wooley, O. W. (1985). Intensive out-patient and residential treatment for bulimia. In D. M. Garner & P. E. Garfinkel (Eds.), *Handbook of psychotherapy for anorexia and bulimia* (pp. 18–24). New York: Guilford Press.